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**TITANIUM AND PHOSPHATE
POTENTIAL OF THE
STEWARTON AND LOWER
COVERDALE GABBRO,
SOUTHERN NEW BRUNSWICK,
CANADA: *A COMPARATIVE
STUDY***

D.V. Venugopal

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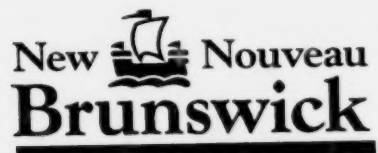
**Titanium and Phosphate Potential of the Stewarton
and Lower Coverdale gabbro, southern New
Brunswick, Canada: *A Comparative Study***

This report has been prepared by:

Minerals, Policy and Planning Division
Department of Natural Resources and Energy
Province of New Brunswick

Hon. Jeannot Volpé
Minister of Natural Resources and Energy

March, 2003



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PLATE

(in back pocket)

Map Plate 2000-30. Geology of the Stewarton Gabbro Complex (parts of 21 H/12 and H/13), Kings County, southern New Brunswick.

Abstract

In southern New Brunswick, mafic and felsic intrusive rocks west of the Town of Sussex near Stewarton and south of the City of Moncton near Lower Coverdale, host magnetite-ilmenite-apatite mineralization. In both areas fine-to coarse-grained disseminations and veinlets of magnetite and ilmenite, and coarse, subhedral to slender prismatic crystals of apatite are largely restricted to gabbroic rocks enriched with pyroxene and amphibole.

At Lower Coverdale several ilmenite and apatite drill hole intersections have confirmed concentrations of titanium in excess of 25% TiO_2 and 12 % P_2O_5 . An occurrence of highly mineralized rock (cumberlandite) in the Stewarton area, is estimated to contain between 45-50% magnetite-ilmenite. The phosphate and fluorine content of fluorapatites in gabbroic rocks of both intrusive complexes are in excess of 40 % P_2O_5 and up to 2% F respectively. Gabbroic rocks are also anomalous in vanadium.

The genetic model considered for the Lower Coverdale Gabbro is that of an immiscibility field represented by thick layers of ferrogabbro enriched in iron oxide, ilmenite and apatite in an anorthosite-gabbro mineral assemblage.

Similarities in lithology, mineralogy, chemistry, texture, structure, and mineralization between the Lower Coverdale and Stewarton intrusions suggest they are coeval lopoliths dominated by gabbro and anorthosite, emplaced during the Early Devonian. It is proposed that anomalous concentrations of iron, titanium and phosphate confirmed at Lower Coverdale may also exist at depth at Stewarton.

Résumé

Dans le Sud du Nouveau-Brunswick, des roches intrusives mafiques et felsiques à l'ouest de la ville de Sussex, près de Stewarton, ainsi qu'au sud de la ville de Moncton, près de Lower Coverdale, abritent une minéralisation de magnétite-ilménite-apatite. Dans les deux endroits, les dépôts disséminés et les filonnets de grain fin à grossier de magnétite et d'ilménite et les cristaux prismatiques hypautomorphes à effilés grossiers d'apatite se limitent en grande partie à des roches gabbroïques enrichies de pyroxène et d'amphibole.

À Lower Coverdale, plusieurs recoupements de trous de sondage d'ilménite et d'apatite ont confirmé des concentrations de titane de plus de 25 % de TiO_2 et de 12 % de P_2O_5 . On estime qu'une venue de roches fortement minéralisée (cumberlandite) du secteur de Stewarton renferme entre 45 à 50 % de magnétite-ilménite. La teneur en phosphate et en fluor des fluorapatites à l'intérieur des roches gabbroïques des deux complexes intrusifs atteint plus de 40 % de P_2O_5 et jusqu'à 2 % de F, respectivement. Les roches gabbroïques présentent en outre des valeurs anormales de vanadium.

Le modèle génétique considéré dans le cas du gabbro de Lower Coverdale correspond à un champ d'immiscibilité constitué de strates épaisses de ferrogabbro enrichies d'oxyde de fer, d'ilménite et d'apatite dans un assemblage minéral d'anorthosite-gabbro.

Les similarités de la lithologie, de la minéralogie, de la composition chimique, de la texture, de la structure et de la minéralisation entre les intrusions de Lower Coverdale et de Stewarton laissent supposer qu'elles constituent des lopolites contemporains où prédominent du gabbro et de l'anorthosite dont la mise en place remonte au Dévonien précoce. On croit que les concentrations anormales de fer, de titane et de phosphate confirmées à Lower Coverdale existent probablement aussi à Stewarton, en profondeur.

Titanium and phosphate potential of the Stewarton and Lower Coverdale gabbro, southern New Brunswick, Canada: *A comparative study*

Introduction

The discovery of a notable titanium resource near Lower Coverdale coupled with favourable projected growth potential for titanium compounds (*i.e.* as a pigment in paint and paper manufacture and as a metal in the manufacture of aircraft and sporting equipment), prompted the Geological Surveys Branch to consider this and other potential sources of titanium mineralization in New Brunswick.

The titanium project commenced with a thorough search of available literature related to geological constraints under which one could expect to find titanium in enough concentrations suggestive of a significant deposit. In order to understand the geological complexities associated with titanium mineralization it is important to know some of its physical and chemical properties.

Discovered over two centuries ago and named after the Titans of Greek mythology, titanium is the ninth most abundant element, making up to about 0.86 % of the earth's crust (Turekian, 1977). Table 1a reflects titanium content and partitioning in common rock suites.

Table 1a. Titanium content and partitioning in common rock suites (Force 1991).

Rock suite	Total TiO₂ %	TiO₂ in oxide minerals (% of total TiO₂)
Igneous		
ultramafic	0.2-0.8	1-4
mafic	0.9-2.7	50
felsic	0.2-0.8	3-30
alkalic	0.1-3.3	3-50
charnockitic	0.4-1.6	50-95
anorthositic	0.1-0.5	50-95
Metamorphic		
gneiss	0.6	5-100
schist and phyllite	0.6	1-77
amphibolite	1.4	15-70
eclogite	1.0-6.0	50-90
Sedimentary		
sandstone	0.2-0.6	10-100
shale	0.6-0.7	n/a
limestone	0.1-0.2	n/a

Titanium metal has an atomic number of 22 and an atomic weight of 47.9. Its specific gravity of 4.51 and a melting point of 1670°C provide the metal with an exceptional high strength to weight ratio. It is also noted for its superior resistance to corrosion. These rather unique properties have resulted in a classification rendering the metal as both strategic and critical.

It appears that most significant titanium deposits in the world occur as an oxide and its occurrence in silicate minerals is not generally of economic importance. Oxide minerals containing in excess of 25 % TiO₂ appear to have an intrinsic or potential value. Table 1b provides typical composition ranges of common titanium minerals.

Table 1b. Composition of common titanium minerals (Force 1991).

Mineral	Chemical composition	TiO ₂ %
Oxide		
Rutile	TiO ₂	>95
Anatase	TiO ₂	>95
Brookite	TiO ₂	>95
Ilmenite	FeTiO ₃	52
Perovskite	CaTiO ₃	59
Magnetite	Fe ₃ O ₄	0-15
Silicate		
Sphene	CaTiSiO ₅	41
Melanitic Garnet	Ca ₃ Fe ₂ Si ₃ O ₁₂	0-17
Biotite	K ₂ (Mg,Fe) ₄ (Fe,Al) ₂ Si ₆ Al ₂ O ₂₀ (OH,F) ₄	0-6
Calcic amphibole	(Na,K)Ca ₂ (Mg,Fe,Al) ₅ Si ₆ Al ₂ O ₂₂ (OH,F) ₂	0-10
Augite	Ca(Mg,Fe)(Si,Al) ₂ O ₆	0-9

Ilmenite, rutile, and anatase are among the most valued titanium oxide minerals. Ilmenite, the most important source of TiO₂, often occurs intergrown with iron oxide minerals which tend to have deleterious effect on overall TiO₂ ore grade. However, weathering and related chemical processes may leach out iron resulting in residual enrichment TiO₂. In the titanium industry, ilmenite includes unweathered ilmenite with less than 50 % of TiO₂ to altered ilmenite containing in excess of 60 % TiO₂. If weathered ilmenite exceeds 70 % TiO₂, it is commonly referred to as leucoxene. Although two polymorphs of rutile, anatase and brookite have similar overall chemical composition they may contain different amounts and varieties of impurities.

The mineralogy of titanium oxide minerals is a critical factor in determining the suitability of a deposit for an intended end use. The market price of concentrate is extremely sensitive to recovery and beneficiation processes required to achieve feedstock requirement.

Potential sources of titanium and phosphate in New Brunswick

Prospective sources of titanium in New Brunswick are largely associated with two types of geological environments: (1) a paleoplacer type, locally represented by paleoplacer

concentrations of titanium and other heavy minerals in clastic sedimentary rocks of Carboniferous age, and in recent near-shore beach sands in the Bay of Fundy region (*i.e.* near Saint John and the Seal Cove area, Grand Manan Island); and (2) a magmatic type, where segregations of titanium-bearing magnetite occur in various mafic intrusive complexes ranging in age from Precambrian to Early Devonian.

This report encompasses a study related to the magmatic type, focused on several mafic and ultramafic intrusive bodies considered as potential host rocks for titanium mineralization. A literature search and study of mineral property assessment reports on file with the Minerals and Energy Division were undertaken to identify intrusive rocks with TiO_2 values in excess of 2 %. This initial prescreening eliminated several areas resulting in the following gabbro bodies being selected for more detailed assessment: Portage Brook, Goodwin Lake, Mechanic Settlement, Saint Stephen, Stewarton, Caledonia Mountain and Lower Coverdale (Figure 1). After follow-up sampling, petrography and chemical analyses of the rocks in these areas, it was decided that Stewarton and Lower Coverdale Gabbro bodies demonstrated geological, mineralogical and chemical characteristics most favourable to host titanium/phosphate mineralization of unqualified economic significance.

Geologic study of the Stewarton Gabbro is augmented by a comparison of core logs, petrographic and mineralogic and geochemical data acquired on a titanium-phosphate-bearing, subsurface gabbro body near Lower Coverdale in southern New Brunswick.

The Stewarton Gabbro

Location and access

The Stewarton Gabbro is located about 25 km almost due west of the Town of Sussex in south central New Brunswick (Figure 1). The intrusive rocks, named after the community of Stewarton, straddle the Sussex and Codys NTS map sheets 21 H/12 and 21 H/13 respectively. From Sussex, access is provided by Highway # 1 and north-bound arterial Highways # 124 and 695 from Norton. From Fredericton, the study area can be reached via the new Fredericton to Moncton Highway #2 southwest to the exit for Cambridge-Narrows and further south on arterial Highway # 695. The East Scotch Settlement Road and several adjacent secondary roads, logging roads and trails, provide adequate routes into key areas of the intrusive body.

Previous work

Historically, the mafic intrusive and related rocks of the Annidale-Stewarton areas have appealed to several explorationists interested in their base metal, gold, and platinum group of elements (PGE) potential.

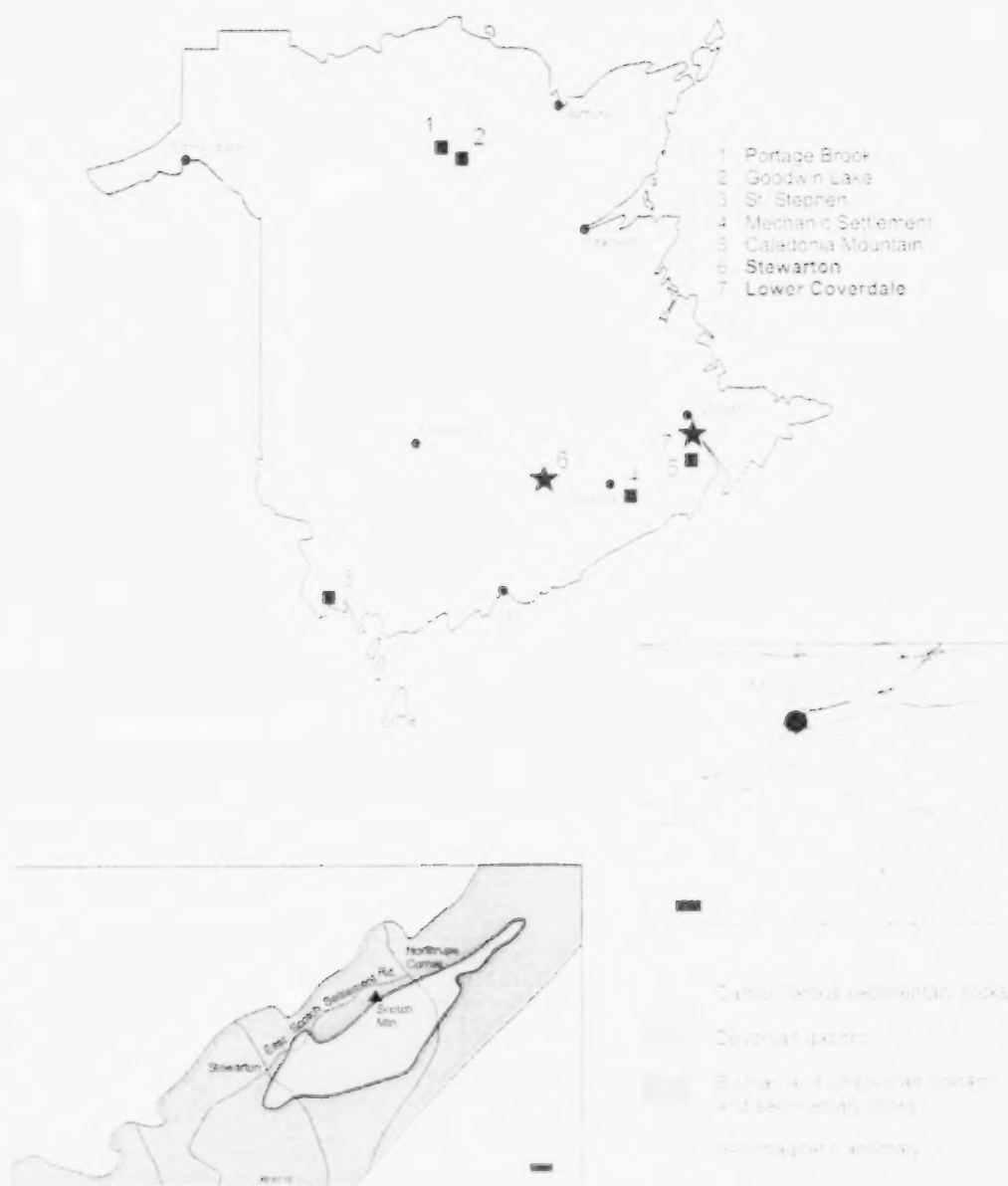


Figure 1. Location of gabbro bodies considered as potential host rocks for titanium and phosphate mineralization in New Brunswick. The Stewart and Lower Coverdale areas were chosen for follow-up study.

In 1943, Jeener first recognized mafic intrusive rocks in the Stewart area, noting several occurrences of gabbro and dioritic rocks near East Scotch Settlement that were enriched in

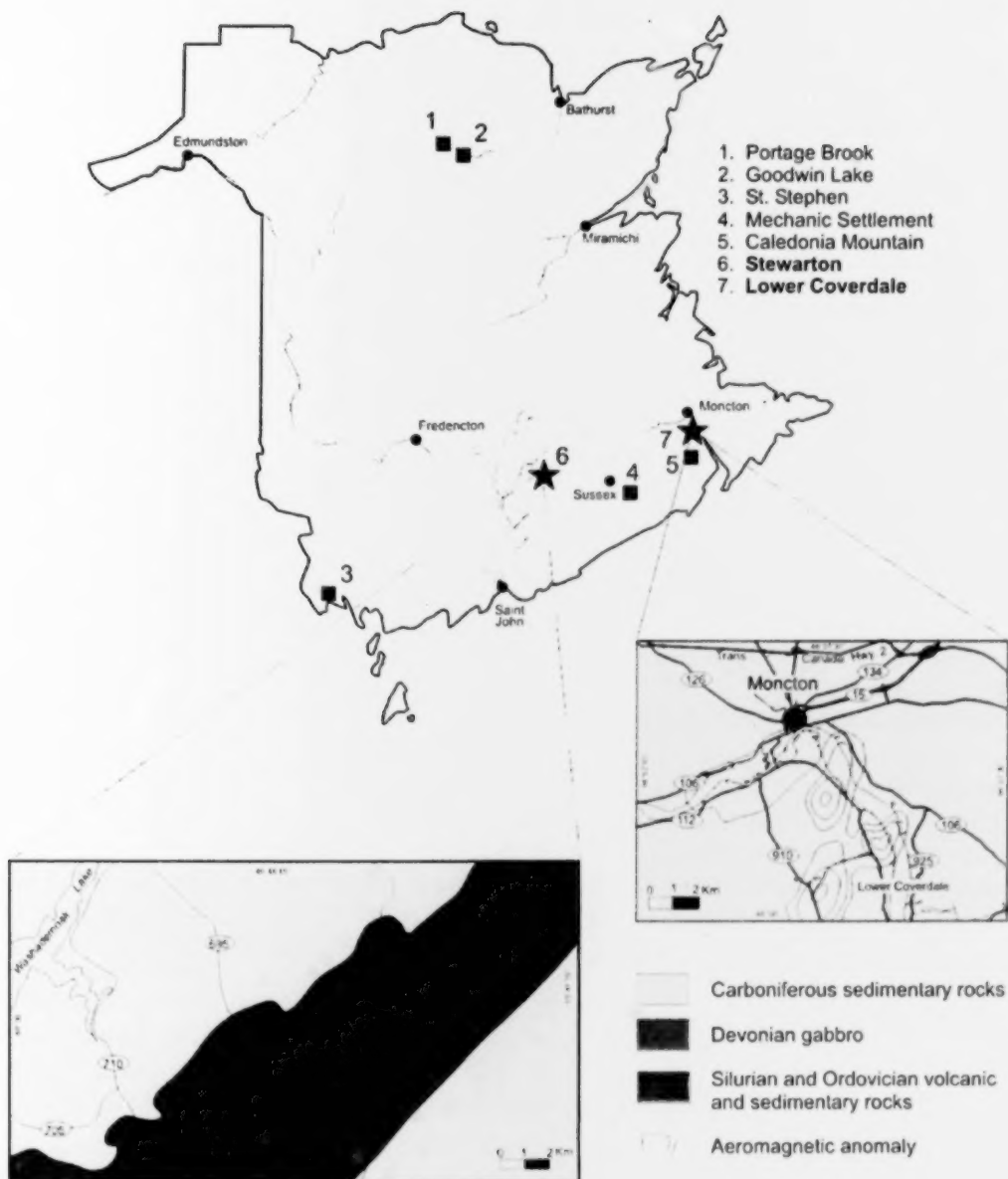


Figure 1. Location of gabbro bodies considered as potential host rocks for titanium and phosphate mineralization in New Brunswick. The Stewarton and Lower Coverdale areas were chosen for follow-up study.

In 1843, Gesner first recognized mafic intrusive rocks in the Stewarton area, noting several exposures of gabbroic and dioritic rocks near East Scotch Settlement that were enriched in

magnetite, a potential source of iron (Gesner 1843). Following Gesner's observations, the Stewarton Gabbro has appeared on regional maps by Bailey et. al. (1880), Alcock and MacKenzie (1946) and Hamilton (1961).

Bennett (1965a and 1965b) carried out a petrological study on the rocks of the complex in 1965, providing the first detailed account of its geology and petrography. In their regional survey of the geology and mineral deposits of the Annidale-Nerepis area in 1987, McCutcheon and Ruitenberg (1987) include a brief geological description and a few chemical analyses of the Stewarton rocks. Paktunc (1987) considered the Stewarton Gabbro a potential target for apatite-rich titanomagnetite deposits as well as platinum-group elements (PGE) and gold (Au). However, preliminary work carried out in 1988 revealed relatively low concentrations of PGE and Au (Paktunc, 1988). In 1993, Tri-Gil Paving and Construction Limited, a Moncton based construction company, opened a quarry immediately to the north of Jack Lake. Seasonally operated, the quarry provides graded aggregate materials for various construction and infrastructure projects in southern New Brunswick. In the early 1990s, Watters (1994) provided a brief account of geology and chemistry of selected rocks within the quarry limits.

Present work

The present geologic investigation of the Stewarton area include:

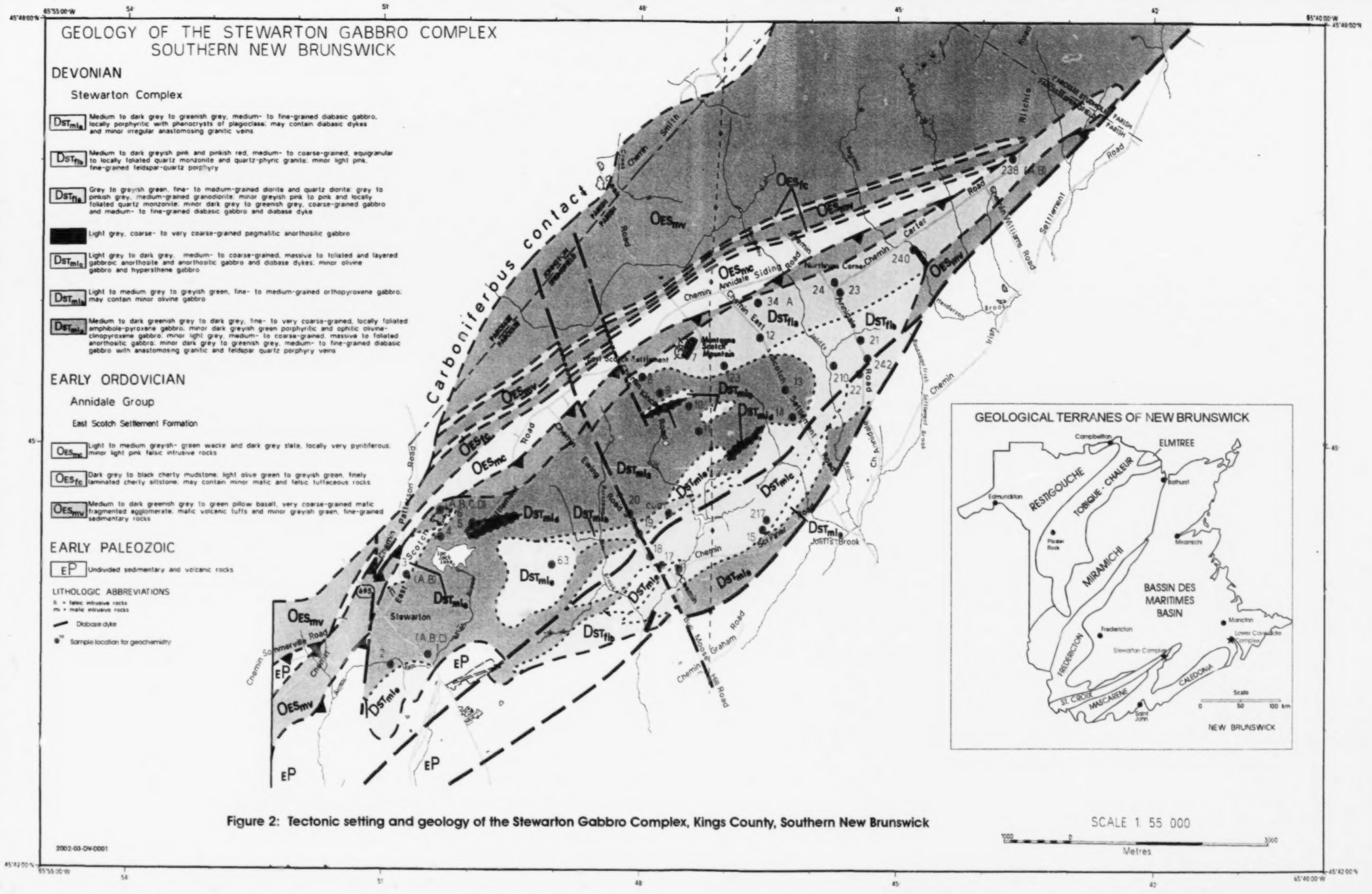
1. Geological mapping of the Stewarton Gabbro and related rocks at a scale 1:25 000 (Map Plate 2000-30).
2. Collecting rock samples from various lithological units of the intrusive for petrographic assessment, and scanning electron microscopic (SEM) work.
3. Geochemical analysis of major and trace elements, and Harker variation and discrimination diagrams.
4. Measuring magnetic susceptibilities and geophysical modeling.
5. Paleomagnetic work on oriented rock samples.

In order to draw comparisons between the Stewarton and Lower Coverdale gabbros the following work was performed:

1. An examination of drill core from a recent diamond drilling program by Noranda Mining and Exploration Inc. and other available core from earlier drilling activity in the Lower Coverdale area.
2. Petrographic and SEM work on several representative cored intervals.
3. Lithogeochemical analysis of drill cores provided by Noranda Mining and Exploration Inc. to generate Harker variation diagrams.
4. Modeling utilizing aeromagnetic (total field), gravity and seismic data.

Physical setting and general land use

The Stewarton and adjoining areas are included in the Moncton Basin physiographic subdivision of Rampton et.al. (1984). The gabbro underlies the divide between the drainage basins of Belleisle Bay to the south and Washademoak Lake to the north. For the most part, the area is characterized by a few rounded hills and low ridges, with broad intervening valleys. Scotch Mountain, situated at the northern edge of the complex, is the most prominent physical feature in



GEOLOGY OF THE STEWARTON GABBRO COMPLEX SOUTHERN NEW BRUNSWICK

DEVONIAN

Stewarton Complex

- DST_{ml}** Medium to dark grey to greenish grey, medium- to fine-grained diabasic gabbro, locally porphyritic with phenocrysts of plagioclase, may contain diabasic dykes and minor irregular anastomosing granitic veins
- DST_{fb}** Medium to dark greyish pink and pinkish red, medium- to coarse-grained, equigranular to locally foliated quartz monzonite and quartz-phyric granite, minor light pink fine-grained feldspar-quartz porphyry
- DST_{fg}** Grey to greyish green, fine- to medium-grained diorite and quartz diorite grey to pinkish grey, medium-grained granodiorite, minor greyish pink to pink and locally foliated quartz monzonite, minor dark grey to greenish grey, coarse-grained gabbro and medium- to fine-grained diabasic gabbro and diabase dyke
- DST_{mr}** Light grey, coarse- to very coarse-grained pegmatitic anorthositic gabbro
- DST_{mc}** Light grey to dark grey, medium- to coarse-grained, massive to foliated and layered gabbroic anorthosite and anorthositic gabbro and diabase dykes, minor olivine gabbro and hypersthene gabbro
- DST_{ml}** Light to medium grey to greyish green, fine- to medium-grained orthopyroxene gabbro, may contain minor olivine gabbro
- DST_{ml}** Medium to dark greenish grey to dark grey, fine- to very coarse-grained, locally foliated amphibole-pyroxene gabbro, minor dark greyish green porphyritic and ophitic olivine-clinopyroxene gabbro, minor light grey medium- to coarse-grained massive to foliated anorthositic gabbro, minor dark grey to greenish grey, medium- to fine-grained diabasic gabbro with anastomosing granitic and feldspar quartz porphyry veins

EARLY ORDOVICIAN

Annidale Group

East Scotch Settlement Formation

- OES_{mc}** Light to medium greyish green wacke and dark grey slate, locally very pyritiferous, minor light pink felsic intrusive rocks
- OES_{fc}** Dark grey to black cherty mudstone, light olive green to greyish green, finely laminated cherty siltstone, may contain minor mafic and felsic tuffaceous rocks
- OES_{mv}** Medium to dark greenish grey to green pillow basalt, very coarse-grained mafic fragmented agglomerate, mafic volcanic tuffs and minor greyish green fine-grained sedimentary rocks

EARLY PALEOZOIC

- EP** Undivided sedimentary and volcanic rocks

LITHOLOGIC ABBREVIATIONS

- fi = felsic intrusive rocks
- mv = mafic intrusive rocks
- = Diabase dyke
- = Sample location for geochemistry

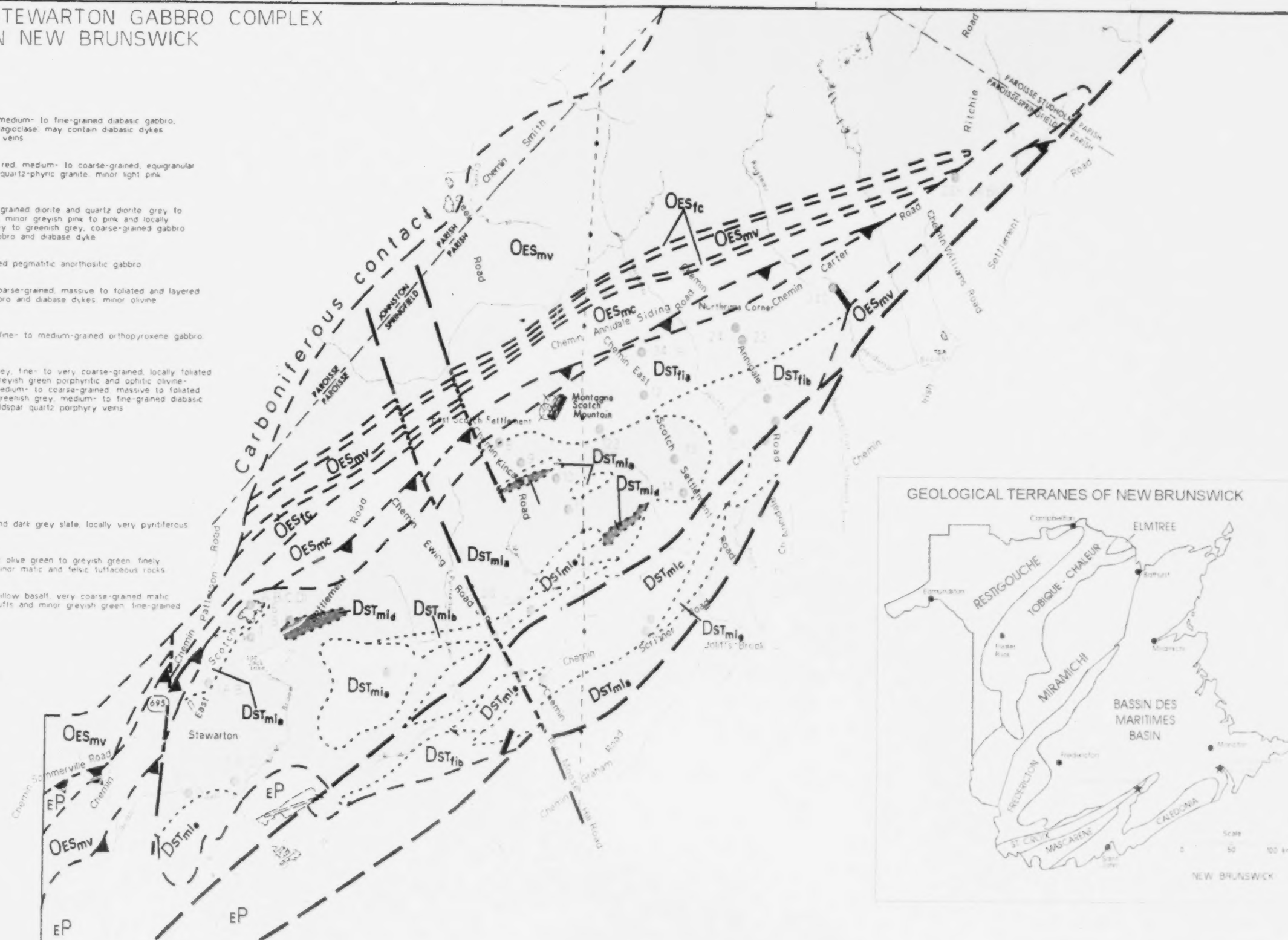


Figure 2: Tectonic setting and geology of the Stewarton Gabbro Complex, Kings County, Southern New Brunswick

The wacke-slate sequence (O_{ESmc} Figure 2), the upper most unit in the formation, consists of a light to medium greyish green, medium- to coarse-grained clastic sedimentary rock, intercalated and interbedded with a dark grey slate, locally very pyritiferous. In some places, the unit contains minor amounts of light pink felsic volcanic rock.

Units not mapped in this study on the southern margin of the Stewarton Gabbro, are variably hornfelsed and comprise an undivided sequence of sedimentary clastics and volcanic rocks, immediately adjacent to the margin of the intrusion. These rocks probably belong to the Late Ordovician-Early Silurian (?) Queen's Brook and Henderson Brook formations (respectively), collectively referred to as the Mascarene Group.

Some of the Carboniferous rocks that unconformably overlie the Lower Paleozoic rocks occur in the area mapped. About 2 km north-northeast of Stewarton Corner, and east of the Patterson Road, an outcrop of Windsor Group limestone unconformably overlies moderate to steeply dipping mafic volcanics. These rocks are overlain by subhorizontal, westward dipping redbeds of the Mabou Group (Figure 3).



Figure 3. Red polymictic conglomerate of the Mabou Group overlying grey, Windsor Group limestone, resting unconformably on deformed mafic volcanic basement. This exposure is located about 2 km north-northeast of Stewarton Corner and due east of the Patterson Road, Kings County, south-central New Brunswick.

Geology of the Stewarton Gabbro

The Stewarton Gabbro is a northeasterly trending lenticular to elliptical intrusive body with a long axis of about 14 km and a maximum width of 3 km. It is mineralogically, texturally and structurally divided into seven lithologic units (Figure 2) based on its relative abundance. They are: (1) ophitic gabbroic rocks (D_{STmia} Figure 2); (2) orthopyroxene-olivine gabbro (D_{STmib} Figure 2); (3) anorthositic rocks (D_{STmic} Figure 2); (4) pegmatitic anorthositic rocks (D_{STmid} Figure 2); (5) dioritic rocks (D_{STfia} Figure 2); (6) granitoid rocks (D_{STfib} Figure 2) and (7) diabasic rocks (D_{STmie} Figure 2). Any unit can contain other lithologies in minor proportion(s). Further, it should be pointed out that the superposition of units in the legend of Figure 2 does not imply the order of emplacement except that granitoid rocks appear to cross-cut all units making it the youngest phase in the intrusive.

Field relationships and petrographic descriptions

Ophitic gabbroic rocks (D_{STmia}): Ophitic gabbro is the most abundant lithological unit in the complex, accounting for about 50 % of all the rock units. This two-pronged northeast trending unit extending from Stewarton to immediately west of Joliff Brook consists predominantly of pyroxene-amphibole gabbro with minor amounts of clinopyroxene-olivine gabbro, anorthositic gabbro, diabasic gabbro and granitoid. A quarry (Figure 4), located about 300 m north of Jack Lake, is one of the several localities that provide excellent exposure of this unit.

The pyroxene-amphibole gabbro (Figure 5) is medium to dark greenish grey and varies from

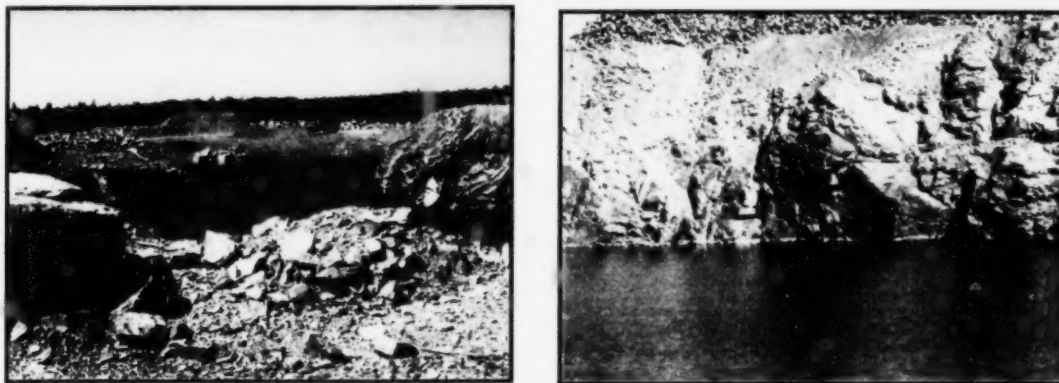


Figure 4. Gabbroic rocks of the Stewarton Gabbro are well exposed in a quarry located about 300 m north of Jack Lake (the Jack Lake quarry), 1.5 km east of Stewarton, Kings County, south-central New Brunswick.

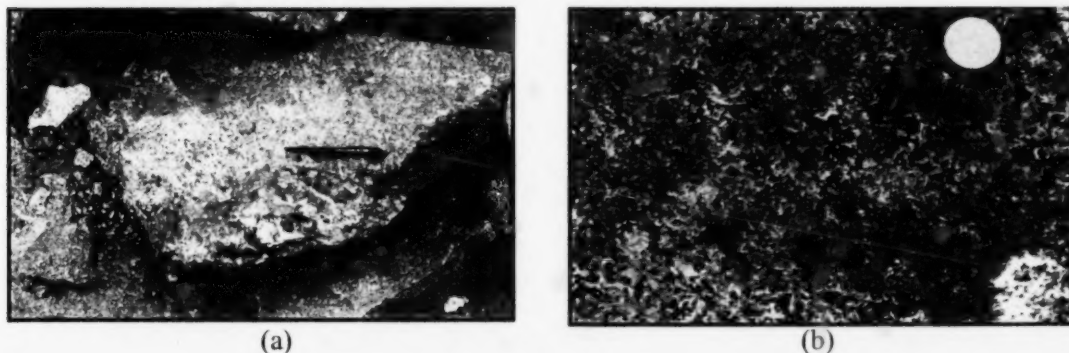


Figure 5. (a) Coarse-to very coarse-grained pyroxene-amphibole gabbro occasionally displaying a pegmatitic texture; (b) close-up view of the rock type in (a).

fine-to coarse-grained and locally to very coarse-grained rock. In places, freshly broken surfaces show a distinctive greyish blue hue probably due to the presence of magnetite and ilmenite. The rock is most commonly medium-to coarse-grained, varying in colour from shades of grey to black on weathered surfaces resulting in a distinctive mottled appearance due to differential relief between the more resistant dark greenish grey to black mafic minerals and the softer, whitish buff plagioclase.

The ophitic gabbro is generally dense and massive showing a subidiomorphic to allotriomorphic granular texture. It is mainly composed of variable proportions of plagioclase, clinopyroxene and amphibole with minor amounts of opaques and apatite. The ophitic nature of the rock is well displayed in thin section (s) where large plates of clinopyroxene and/or amphibole totally or partly enclose smaller prismatic crystals of plagioclase. Locally in some rocks, minor amounts (< 5 %) of olivine are represented by the alteration minerals talc, serpentine, iddingsite and/or bowlingite. Pyroxene is partially to totally altered to fibrous amphibole, biotite and chlorite. In a few pyroxene crystals, exolved ilmenite and magnetite occur along cleavage planes. It is difficult to determine optically whether all of the amphibole is an alteration product of pyroxene. Plagioclase (An₅₅₋₆₅) is fresh to variably altered. Although plagioclase commonly shows albite and pericline twinning, there are a few grains that show carlsbad, albite and pericline twinning. Invariably the plagioclase displays oscillatory zoning. Abundant magnetite which is reflected in the rock being moderately to strongly magnetic, ilmenite and minor amounts of disseminated pyrite and chalcopyrite are also present.

The ophitic gabbro unit is interlayered with dark grey to dark greyish green olivine-pyroxene gabbro. As observed on the northern face of the Jack Lake quarry, the olivine-pyroxene gabbro displays unique textural and mineralogical features. Steeply dipping layers of olivine-pyroxene gabbro vary in thickness from a few centimeters to about 1.5 m. On weathered surfaces, the layered rock contains clusters or aggregates of clinopyroxene measuring up to 2 cm in diameter (Figure 6) forming a porphyritic texture that is variably described as cumuloaphyric, glomeroporphyritic or gregaritic. In thin section, these large, irregular to subhedral-shaped plates of clinopyroxene contain laths of plagioclase and olivine and fresh prismatic crystals of plagioclase and subrounded to subhedral olivine crystals are optically unorientated. The groundmass of this rock is composed of clinopyroxene, plagioclase and olivine with minor amounts of magnetite, ilmenite and apatite. Figures 6 and 7 show the rock specimen and corresponding photomicrographs.

North-northwest of Jack Lake in the area between the Patterson and East Scotch Settlement Roads, other variations of gabbro can be seen in the form of pods, lenses and layers of anorthosite. At this locality, a gabbroic anorthosite displays an increase in the plagioclase content relative to mafic minerals. There is seldom a sharp boundary or contact with the host rocks, and the transition seems to be quite gradational in terms of grain size and plagioclase content. The ophitic gabbro unit also contains minor amounts of diabasic gabbro, veins of granite and feldspar quartz porphyry as seen in the southern part of the Jack Lake quarry and in blueberry fields east of the Patterson Road.

At the Jack Lake quarry and adjacent the Scotch Settlement Road, exposures of ophitic gabbro and related rock types show a faint to a fairly well developed fabric as a consequence of the crude orientation of plagioclase and mafic minerals. In all the rocks of this unit in the quarry, an obvious feature is the presence of thin films, small patches, pods, veins and fracture fillings of lemon yellow epidote and yellowish green to dark green chloritic minerals.

Orthopyroxene gabbro (D_{STmb}): A thin lenticular band of orthopyroxene gabbro that is restricted more-or-less to the southwestern part of the Stewarton Gabbro, occurs about 1.0 km east of Jack Lake. It tapers off at both ends laterally against a diabasic gabbro unit (Figure 2).

Scattered outcrops of orthopyroxene gabbro occur elsewhere in the complex associated with other gabbroic rocks.

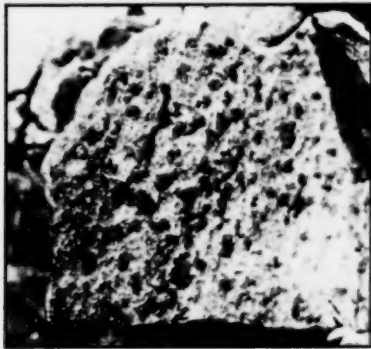
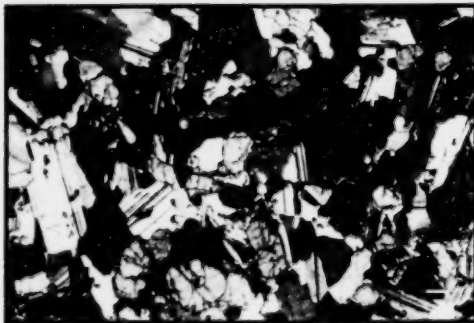


Figure 6. Coarse-grained aggregates of clinopyroxene in a porphyritic olivine-pyroxene gabbro from the Jack Lake quarry, 1.5 km east of Stewarton, Kings County, south-central New Brunswick.



(a)

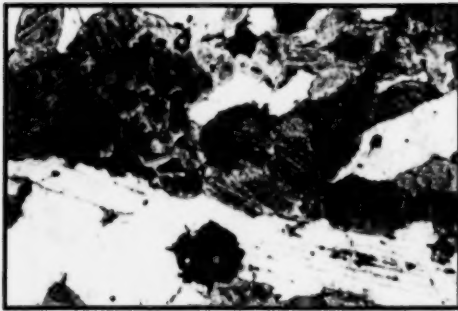


(b)

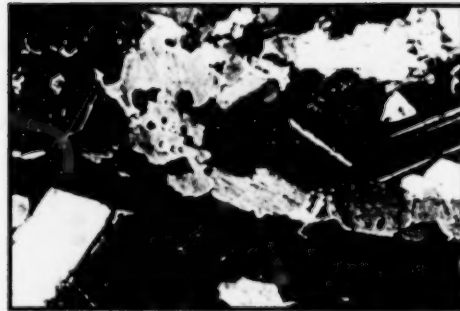
Figure 7. (a) Photomicrograph displaying cumulates of olivine, plagioclase, clinopyroxene and interstitial opaque oxides. (b) Large plates of clinopyroxene with laths of plagioclase and subhedral to irregular olivine displaying ophitic to subophitic texture in a glomeroporphyritic pyroxene-olivine gabbro. (Crossed polars; scale 1cm=1mm).

The orthopyroxene gabbro is typically a grey to greyish green, generally fine-to medium-grained and occasionally coarse-grained rock, displaying greyish brown weathering surface and consists of essentially orthopyroxene cumulates along with plagioclase and minor amounts of clinopyroxene (inverted from pigeonite) and interstitial opaque oxides such as magnetite and ilmenite (Figure 8). Texturally, it is granular with subrounded to subhedral crystal boundaries. Minor amounts of olivine (Figure 9), locally deformed and altered to serpentine, talc and chlorite are also present.

The orthopyroxene in the gabbro displays exsolved lamellae of clinopyroxene parallel to the monoclinic plane (001). This exsolution event takes place during the slow cooling of pigeonite when the temperature drops below the inversion point. Finely exsolved laminations develop parallel to the twin plane (100) as a result. The combined effect of these two sets of twin lamellae give rise to a herringbone structure well displayed in these rocks (Figure 9). The subhedral long prismatic plates of plagioclase (An_{55-60}) are relatively fresh showing well developed albite and carlsbad twinning.



(a)



(b)

Figure 8. (a) Photomicrograph showing typical cumulates of plagioclase and pyroxene in medium-to coarse-grained orthopyroxene (hypersthene) gabbro, from the Stewarton Gabbro, Kings County, south-central New Brunswick. [(a) Plane-polarized light (b) Crossed polars ; scale: 0.85 cm=1mm.

A subcrop of a mineralized rock referred to as cumberlandite (Bennett 1965b) occurs in the northeastern part of the orthopyroxene gabbro unit (Figure 4.7, Appendix 4). It is a steel grey, massive, dense rock composed of 45-50 % olivine, 5-10 % plagioclase, 45-50 % opaque oxides (magnetite+ilmenite) and 1-2 % rutile (Figure 10). The olivine component of the rock shows rims of kaersutite (titanium-bearing amphibole) (Figure 10c) and other alteration minerals such as serpentine, talc, bowlingite and iddingsite. Plagioclase twins are bent and display slight alteration to sericite.

Anorthositic rocks (D_{STmic}): The second most abundant rock unit in the Stewarton Gabbro, constituting 15 to 20 % of the map area, is anorthosite. These rocks are mostly restricted to a northeast trending lenticular belt approximately 1.5 km wide and extending 4 km along the southern margin of the complex.

This unit contains primarily anorthositic gabbro and gabbroic anorthosite with minor rocks from the other suites. Diabase is very common throughout the unit varying from isolated exposures to extensive areas of outcrop, and dioritic to granodioritic rocks occur in the southwestern part of the unit. This unit also locally grades into pyroxene-amphibole-bearing gabbroic rocks. Thin lenticular bands and irregular patches of coarse- to very coarse-grained labradorite are found in the northwest part of the unit adjacent the contact with gabbroic rocks.

The anorthositic rocks vary from light greenish white to dirty white, and light to dark grey. These colour variations can be seen in an area northwest of Scribner Road and along trail (old railway line) immediately west of Joliff Brook. The rocks are massive and often display rhythmic and cryptic layers from thin "inch layers", 2 to 6 cm thick (Figures 11 and 12), to layers over 1 meter thick. Examples of these occur along the East Scotch Settlement Road and in blueberry fields north of the Scribner Road. Within the more massive layers, a faint-to well-developed foliation, resulting from the parallel and subparallel alignment of mafic minerals is prevalent towards the bottom of each layer. The bottom part is comprised of a cumulate of mafic silicates and opaque oxides (Figure 12). The coarser-grained or upper part are rich in leucocratic minerals comprised mostly of plagioclase.

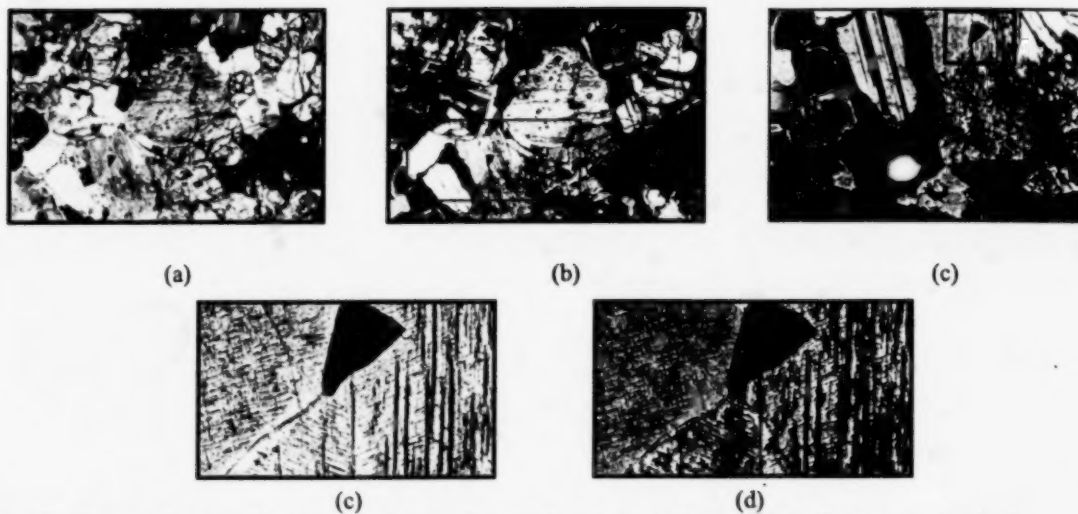


Figure 9. Photomicrograph showing hypersthene after inverted pigeonite displaying typical herringbone structure. (a) Plane polarized light , scale: 0.95 cm=1mm; (b) crossed polars; scale: 0.95 cm=1mm (c) inset of b scale: 1.85cm=1mm (d) inset of c, plane polarized light, scale: 7.35 cm =1mm and (e) inset of c, crossed polars, scale: 7.35 cm =1mm

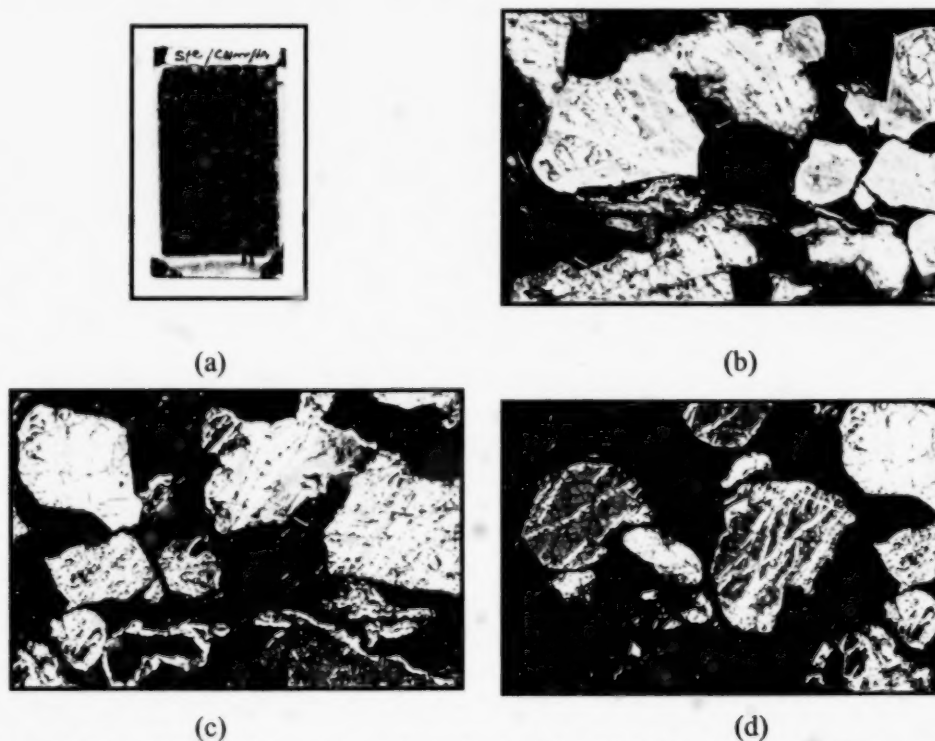
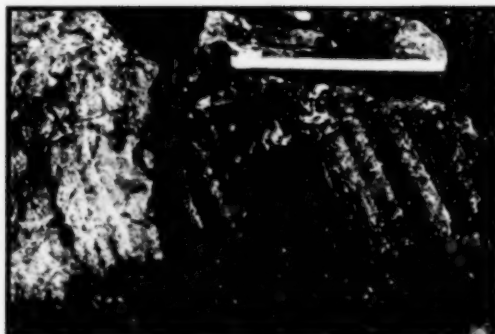


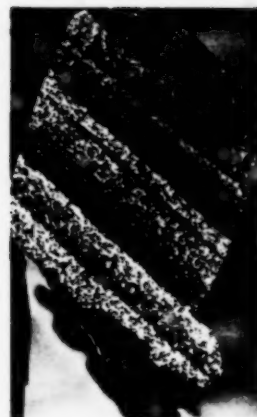
Figure 10.

Photomicrographs (b, c and d) showing mineral content, alteration and texture in a mineralized (high Ti) sample of cumberlandite (a), about 2 km east of Jack Lake, Kings County, south-central New Brunswick

Figure 10 (cont'd) (a) thin section of cumberlandite: 45-50% olivine; 45-50% opaque oxides (*i.e.* magnetite and ilmenite) and up to 10% clinopyroxene and plagioclase, scale: 1cm=1.25cm (b) plane polarized light, scale: 1.45cm=1mm (c) crossed polars; note alteration rim of kaersutite (amphibole) around olivine, scale: 1.45cm=1mm (d) olivine and plagioclase, crossed polars, scale: 1.45cm=1mm.

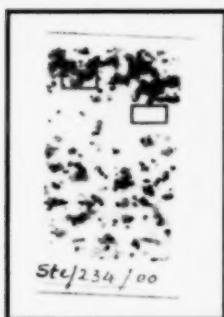


(a)

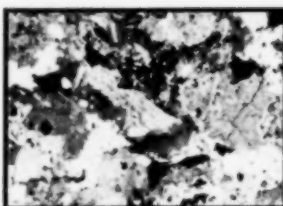


(b)

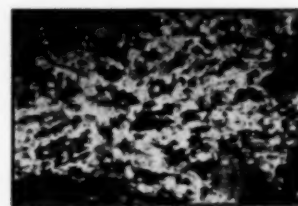
Figure 11. (a) Outcrop of layered anorthositic gabbro, about 2.5 km east of Jack Lake, Kings County, south-central New Brunswick. (b) A polished slab of gabbro featured in (a) showing rhythmic, cryptic and graded layering with concentrations of denser mafic silicate minerals and iron-titanium-rich oxides at the bottom of each layer. (Scale 1cm=5.3cm).



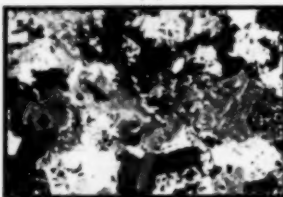
(a)



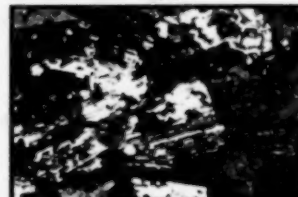
(b)



(c)



(d)



(e)

Figure 12. Photomicrographs (b,c,d and e) of mafic and felsic components in a layered anorthositic gabbro of the Stewarton Gabbro, Kings County, south-central New Brunswick. (a) thin section demonstrating layering in anorthositic gabbro, scale: 1cm=1.1cm. (b) and (c) Mostly cumulates of mafic minerals, opaque oxides and minor plagioclase (Plane polarized light, scale: 0.6 cm=1mm). (d) and (e) Mostly plagioclase and minor mafic cumulate minerals and opaque oxides (crossed polars, scale: 0.6 cm=1mm).

The intermediate part of the layer shows a gradual transition from dark to light material. Grain size coarsens upward in each layer, the reverse of what normally would be expected in a typically graded sedimentary clastic sequence. One explanation of this layering feature could be that the constituents of the melt were undergoing gravitational settling accompanied by

differentiation and fractionation. Although the rhythmic layering is fairly obvious, cryptic variation is modified due to overprinting by hydrothermal alteration.

Pegmatitic anorthositic gabbro (D_{STmid}): Pegmatitic anorthositic gabbro, comprising only 1 to 2 % of all lithologies in the map area, are found at three localities (Figure 2) and represent a coarse-to very coarse-grained pegmatitic phase of the gabbroic and anorthositic suites. The best exposures can be seen on the north side of the East Scotch Settlement Road, about 600 m northeast of Jake Lake (Figure 13a). Others are found adjacent to the road about a kilometer east of Jack Lake, and in an area bounded by the Kincade, East Scotch Settlement and Scribner roads (Figure 13b).

The pegmatitic zones trend roughly northeast and have outcrop widths varying from 1 to about 20 m. These rocks resemble labradorite and display a crude foliation as a result of the subparallel orientation of aggregates and/or prismatic crystals of plagioclase bounded by long (up to 5 cm), subhedral to euhedral plagioclase laths (Figure 13a).

The rock is coarse-to very coarse-grained and usually displaying a characteristic pegmatitic texture. The inter-plagioclase area is speckled with coarse-grained mafic minerals and opaque iron and titanium oxides. The plagioclase does not exhibit a schiller effect (*i.e.* a play of color due to the arrangement of minute inclusions in the crystal), typical of labradorite.

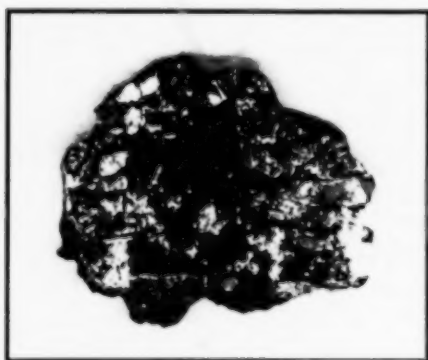
Diabasic gabbro (D_{STmie}): Diabasic gabbro is ubiquitous throughout the complex and is the fourth most abundant lithology comprising 8 to 10 % of the map area. It occurs as dykes, sills, sheet-like bodies and irregular patches mostly within the gabbroic and anorthositic suites, and to a lesser extent within the felsic rocks of the complex. Dykes and sills vary from a few centimeters to about 3 m in width, but their lateral extent is unknown. Although the rock type occurs here and there throughout the gabbro, mappable concentrations can be seen only in the southern and southwestern extremity of the gabbro body and to a lesser extent as small blobs in an area west and southwest of a north-south trending power-line near Scotch Mountain.

Diabasic gabbro is typically dark grey to black, fine-grained, massive, dense rock displaying a light to medium greyish to greenish buff weathering surface. Locally the rock is porphyritic with phenocrysts ranging from 3 to 5 mm-long euhedral crystals of plagioclase accounting for up to 10 % of the rock. Due to their resistance to weathering, these rocks often occur as knobs and ridges in the higher ground of the Stewarton area.

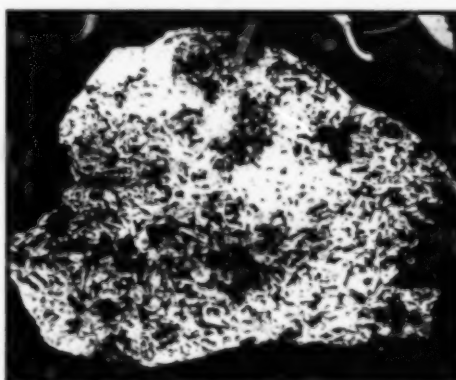
Near the southwestern limits of the complex, an elliptical-shaped area of diabase is sheared and faulted against hornfelsed country rocks and other gabbroic rocks of the complex. The diabase maintains a well-developed cataclastic fabric in the vicinity of faults and related shear zones, well displayed near a microwave tower on the western flank of the Scotch Mountain. Here diabasic gabbro is cut by several sets of fractures that carry chlorite and epidote group minerals. Diabasic gabbro shows six types of contact relationships with the gabbroic and anorthositic rocks of the Stewarton area, which indicate that there may have been several pulses or phases of diabasic gabbro intrusion coeval with the high-level granitoid intrusions described in the following:

1. Sharp contacts with little or no chilled margin are common.

2. Contacts where the host-rock clearly developed varying widths of chilled margin (Figure 2.5, Appendix 2).
3. A cusped contact (Figure 14) resembling a soft-sediment load structure (Figure 1.1, Appendix 1 and Figure 2.4, Appendix 2).
4. A wavy (Appendix 2, Figure 2.1) and spheroidal structure (Appendix 2, Figure 2.2) seen in an area of blueberry fields, about 300 m west of Jack Lake.
5. Irregular blocks of porphyritic diabasic gabbro in anastomosing quartz-feldspar rock cut by medium-to fine-grained granitoid rock (Appendix 2, Figure 2.3).
6. Diabasic gabbro occurring as inclusions and embayments, and as a partially or completely assimilated fraction within felsic rocks intruding the gabbroic suite. This is well displayed at the Jack Lake quarry (Figures 1.3 and 1.4, Appendix 1). In this case, the felsic rock shows a band of chilled margin, which in turn includes partially assimilated diabasic rock. While the contact between the coarse grained gabbro and felsic dyke is sharp and planar, the border between diabasic rock and felsite is irregular, seriate and curvilinear.



(a)



(b)

Figure 13. Pegmatitic anorthositic gabbro of the Stewarton Gabbro, Kings County, south-central New Brunswick. (a) located about 600 m east of the Jack Lake quarry adjacent the East Scotch Settlement Road and (b) located about 1 km south-southwest of Scotch Mountain.



Figure 14. Dykes and anastomosing veins of feldspar-quartz porphyry and granite cutting diabasic gabbro. The outcrop is located at the intersection of Kincade Road and a power line.

Dioritic and granodioritic rocks (D_{STna}): Dioritic and granodioritic rocks vary in colour, texture and composition, and constitutes about 10 % of the complex (Figure 2). Although they are primarily restricted to the northeastern part of the gabbro body, scattered outcrops occur in other lithologic units of the Stewarton area as isolated and irregular lenses, dykes, sills, fracture fillings and veins.

This rock unit forms a lenticular body extending over a distance of about 8 km in a northeasterly direction. It is composed largely of diorite, quartz diorite and granodiorite with minor amounts of quartz monzonite, leuco-granite and felsite. It is difficult to estimate the proportions of these rock types due to lack of exposure. A well-exposed section in Joliff Brook, outcrops along the northern section of Henderson Brook and exposures near the microwave tower on Scotch Mountain best demonstrate the distribution of the various lithologies within the unit. The northern and part of the southern boundaries of the unit are intrusive into surrounding country rocks.

Diorite and quartz diorite (Figure 3.1, Appendix 3 and Figures 4.3 and 4.4, Appendix 4), which constitute the most abundant rock types in the unit, are typically medium to light grey, fine-to medium-grained, and generally massive, occurring in sharp and gradational contact with gabbroic, anorthositic, and diabasic rocks. The gradational feature is well displayed in a section exposed on Joliff Brook. At the Jack Lake quarry, as displayed in a few broken rock fragments, diorite intrudes gabbroic rock with a sharp contact on one side while on the other side its contact is represented by a chilled reaction zone. The diorite shows irregular patches of partially assimilated diabase. Bordering the coarse-grained gabbro, a zone, about 2 to 3 mm wide, probably related to shearing, contains chlorite and epidote group minerals. In the proximity of fault and shear zones, dioritic rocks show a well-developed penetrative fabric with cataclastic textures (*i.e.* near the microwave tower on Scotch Mountain).

Granodiorite forms only a small percentage of the suite and is a light to dark pinkish grey, medium-to coarse-grained rock that commonly occurs in proximity to shear zones. It is generally well foliated displaying a strong cataclastic cleavage (Figures 3.3 and 3.6, Appendix 3). It appears that it is a result of the hybridization of rocks of granitic and gabbroic composition along shear zones.

Other minor rock types that occur in this suite include quartz monzonite, gabbro, and diabase. The quartz monzonite, a fine-to medium-grained greyish pink to pink and locally foliated rock, occurs invariably adjacent to granodiorite. The gabbroic rocks occur as xenoliths of various sizes in the dioritic and granodioritic rocks, and the peripheral parts of the gabbro are hybridized.

A distinctive diabasic dyke, trending roughly north-northwest with a subvertical dip, occurs on Henderson Brook near the contact between the dioritic unit and older mafic volcanic rocks of the East Scotch Settlement Formation.

Quartz monzonite, quartz-phyric granite and feldspar-quartz porphyry (D_{STnb}): The rocks of this unit are restricted to two main areas within the gabbro. The larger occurs along the southern border of the dioritic unit and the smaller occurs in the southwestern part of the complex. Different rock types of this unit can be seen along the southern half of Joliff Brook, in an unnamed brook west of Joliff Brook and in parts of Elm Brook. Isolated outcrops are

encountered along some of the southwest trending logging roads cutting the complex at various locations and in the Jack Lake quarry.

The unit is partly in contact with dioritic rocks (D_{STfa}) to the north, whereas in the south, it is in faulted contact sedimentary and volcanic host rocks (Unit eP). The granitoid rocks of this unit appear to be the last intrusive phase in the complex. The rocks of this unit, occur randomly throughout the complex particularly within the diabasic gabbros as wisps of various shapes and sizes, as anastomosing veins (Figure 1.5, Appendix 1) and small lenses.

Quartz monzonite constitutes about 50 % of this unit. It is a massive to foliated, light pink to dark greyish red, fine -to medium -grained rock (Figure 3.2, Appendix 3). Where the rock shows foliation, it is often due to the presence of cataclastic cleavage. The rock is composed of 10 to 25 % quartz, 35 to 40 % plagioclase, 25 to 30 % potash feldspar and 5 to 20 % mafic minerals, amphibole (after pyroxene), biotite and chlorite and rarely clinopyroxene. Locally the rock is porphyritic with phenocrysts of feldspar and aggregates of mafic minerals in a fine-grained matrix of quartz and feldspar.

Quartz-phyric granite is the second most abundant rock type in this unit. The best exposures of this rock can be seen in Joliff and Elm brooks with more isolated outcrops seen about 1.5 km south of Northrups Corner on the Annidale Road. The rock is typically greyish red to brick red, medium-to coarse-grained rock (Figure 3.4, Appendix 3) seldom displaying a foliation. One of its distinguishing features is the presence of milky white quartz phenocrysts in a red quartzofeldspathic matrix. The quartz phenocrysts, 2 to 4 mm in diameter, account for about 50 % of the rock. The red color is probably due to iron oxide derived from the limonitic and goethetic alteration of mafic minerals.

Feldspar-quartz porphyry is not as abundant as other rock types in this unit, but is fairly widespread throughout the complex. It is invariably associated with diabasic gabbroic rocks and typical exposures can be seen on the south wall of the Jack Lake quarry. It is a light greyish pink to salmon pink and dark pink, mostly fine-grained rock, displaying a chalky white weathering surface. In the quarry several textural and structural variations can be seen. One variation is a well-developed compositional layering (Figure 1.2, Appendix 1) a few cm to about a meter. The color of the layers can vary from shades of grey to pink, reflecting different mineralogical and chemical compositions and a few layers show wispy xenoliths of gabbroic and diabasic gabbroic rocks (Figures 1.3 and 1.6 Appendix 1) when in sharp contact with coarse-grained ophitic gabbro. The porphyry develops load cast and cast-like structures. Features related to assimilation, grain size reduction and gradation in the proximity of contact areas are also discernible in the quarry.

The porphyry (Figure 4.8, Appendix 4) is composed essentially of 25 to 30 % phenocrysts of feldspar in a feldspar-quartz matrix. With a reduction in the number of feldspar phenocrysts the rock grades to an equigranular granitic composition. The mafic constituents of this rock may vary from <5 % to slightly over 10 % in the dark layers. In a few feldspar-quartz porphyry and granite samples, miarolitic cavities, myrmekitic and granophyric textures have been observed suggesting granitoid rocks are formed from a fairly water-rich, high-level intrusion.

Mineralogy and alteration of mafic rocks

Table 1 presented in Appendix 6 summarizes selected petrographic features of typical rock types from the Stewarton Gabbro. Included are: principal, accessory, alteration, and vein minerals, textures and structures, and grain size. Modal values for various minerals are estimated.

In all gabbroic rocks of the complex, plagioclase, clinopyroxene, orthopyroxene, olivine are the main mineral phases. Opaque oxides including magnetite, ilmenite and apatite, are secondary minerals.

Plagioclase: The plagioclase content and grain size in the gabbroic rocks is highly variable. Crystals range from 0.01 mm in diabasic gabbros to almost 4 cm in pegmatitic gabbros. Plagioclase occurring as cumulates and intercumulates are euhedral prismatic, equant to lath shaped and subhedral grains varying in degrees of alteration. Unaltered and less altered plagioclase typically display albite twinning, however carlsbad and pericline twinning are also seen. Although distinct zoning is not commonly observed, irregular and undulose extinction suggests a slight variation in the composition of plagioclase from core to the periphery of some crystals. In a few ophitic gabbro samples, some plagioclase grains contain tiny patches of exsolved K-feldspar displaying antiperthitic texture. The general composition of fresh (unaltered) plagioclase (determined by measuring in the symmetrical zone in thin sections normal to the x-axis) is labradorite to andesine (An_{65-40}). The plagioclase in medium-to coarse-grained gabbroic rocks tends to be more calcic than that of diabasic gabbro. In the coarse- to very coarse-grained ophitic gabbro, poikilitically occurring tiny laths of plagioclase are clear and inclusion free whereas the coarser grained plagioclase of other rocks contain inclusions of clinopyroxene, apatite and opaque minerals suggesting simultaneous crystallization. Plagioclase is variably sericitized and altered to saussurite and saussuritized plagioclase occurs in veins and fractures. In some rocks, plagioclase is dusted with iron oxide and iron carbonate.

In the dioritic rocks, plagioclase is andesine to oligoclase (An_{40-20}) in composition and is generally sericitized and saussuritized. In the granitoid rocks, plagioclase is characterized by oligoclase to albite (An_{25-10}) composition.

Olivine: Olivine, like some of the plagioclase, is one of the cumulate minerals and occurs as discrete tiny grains, aggregates of grains and as inclusions in large plates of clinopyroxene. Olivine grains are often subhedral, subrounded to irregular in shape and typically fractured. It is altered to a variety of minerals including kaersutite, serpentine (fibrous), talc (flamboyant) and fine aggregates of bowlingite and iddingsite and chlorite (blue). Olivine that occurs as inclusions in large crystals of plagioclase and clinopyroxene in porphyritic gabbro and in cumberlandite is least altered. Rarely in a few ophitic gabbro samples, olivine displays a corona structure against pyroxene, plagioclase and amphibole. Scanning electron microprobe (SEM) chemical analysis of olivine in a mineralized cumberlandite sample indicates that it is Fo_{67} (Table 2b).

Clinopyroxene: The various grain sizes of clinopyroxene are generally subhedral to irregular in shape. It is a cumulate to intercumulate mineral and as described earlier, it always is associated with inclusions of other minerals. It is typically straw yellow to medium brown pleochroic in thin section and displays a very high birefringence. The optical properties and chemistry indicate that clinopyroxene has a diopside-salite range of composition and contains thin rods and tiny blebs of magnetite and ilmenite along its cleavage planes.

Clinopyroxene is variably, but commonly pervasively uralitized. Invariably, the intensity of alteration decreases from peripheral areas of the grain towards its core and in some places, the clinopyroxene cores are left unaltered. Locally, yellowish brown to brown pleochroic kaersutite replaces the clinopyroxene and in a few cases, clinopyroxene and amphibole show dark brown biotite along cleavages. Other alteration minerals include actinolite, aggregates of fine-grained chlorite, epidote group minerals, sphene and carbonate.

Orthopyroxene: Orthopyroxene is hypersthene developed from the inversion of pigeonite. It is not as common as clinopyroxene in rocks of the Stewarton Gabbro and is generally restricted to orthopyroxene gabbro and olivine gabbro. It occurs as subrounded, subhedral to irregular grains largely intercumulate to clinopyroxene and plagioclase (Figure 9a) displaying a herringbone structure and a set of thin exsolution lamellae of diopside.

Amphibole: Amphibole (hornblende) is the most commonly observed and stable mineral phase in the gabbroic rocks and most is believed to be of secondary origin. A few SEM chemical analyses indicate hornblende varies in composition from high iron and low magnesium to high magnesium and low iron varieties. Hornblende of high magnesium and low iron is high in titanium compared to the high iron and low magnesium type. Magnetite and ilmenite occur along the cleavages in amphibole and tiny prismatic apatite crystals are ubiquitous in the amphibole in some gabbroic rocks.

Fe-Ti oxides: Metallic oxides, including magnetite and ilmenite, are intercumulates in the gabbroic rocks and occur as intergranular grains and locally in veinlets of nelsonite. In reflected light, the magnetite and ilmenite show various types of exsolution textures. Other textures including myrmekitic, skeletal and cauliflower, suggest a secondary origin for these oxides. In a few samples, magnetite and ilmenite are partially altered to hematite and rutile/anatase respectively. In dioritic and granitoid rocks, oxides are minor to absent.

Apatite: Apatite is an important accessory mineral and generally occurs as discrete fine, and locally of coarse, euhedral to subhedral prismatic crystals and as inclusions in amphibole, plagioclase and clinopyroxene. It also occurs as irregular patches with magnetite and ilmenite in nelsonite veins. The 2V angle in a number of apatite grains was observed to be about 20° and chemical analysis by SEM methods indicate it is enriched in fluorine.

Alteration minerals: Most rocks of the intrusive complex are altered to varying degrees. Table 1, Appendix 6 summarizes the main alteration products as derived from their parent minerals. The alteration of pyroxenes and olivine could be due to hydration and autometamorphism. However, subsequent alteration mineral assemblages, such as epidote group minerals, chlorite, and prehnite of sub-greenschist facies, may be associated with hydrothermal activity related to a late high-level granitoid porphyry intrusion.

Lithogeochemistry

Forty rock samples were analysed at Actlabs for major element oxides and trace and rare earth elements using ICP and INAA methods. Analytical results are presented in Tables 1 and 2 in Appendix 7 along with a chemical classification and nomenclature of various rock types using total alkalis vs silica is presented in (Figure 7.1). At the bottom of Table 1 (Appendix 7) is the

chemical composition of several rock type suites selected from the literature for comparison. Major element oxides and calculated normative values are included in Table 3 (Appendix 7).

Major element oxides : Major element oxides analyzed include SiO_2 , TiO_2 , Al_2O_3 , $\text{Fe}_2\text{O}_3^{\text{Total}}$, MnO , MgO , CaO , Na_2O , K_2O , P_2O_5 and LOI (loss on ignition). The SiO_2 in the gabbroic rocks varies from about 35 to 60 %, while that of dioritic and granitic rocks of intermediate to felsic composition vary from 60 to 77 %. A mineralized sample of cumberlandite characterized by a SiO_2 value of only 15.98 % displays anomalous values of other oxides, particularly very high TiO_2 and Fe_2O_3 , and therefore stands out in all of the Harker variation plots presented in figures 15 to 17.

Features displayed in variation diagrams are noted below:

TiO_2 : Values vary from 0.51 to 7.82 % in many gabbroic samples that are above normal for similar rocks (bottom of Table 1, Appendix 7). TiO_2 vs SiO_2 (Figure 15) shows a general negative correlation and a cluster of gabbroic rocks with anomalous values of titanium oxide (TiO_2).

Al_2O_3 : The plot of Al_2O_3 vs SiO_2 (Figure 16) shows positive correlation. It is important to note that gabbroic rocks with anomalous TiO_2 have lower values of alumina suggesting a strong affinity to mafic constituents relatively low in alumina. Anorthositic rocks have higher values of Al_2O_3 reflecting their higher feldspar (plagioclase) content.

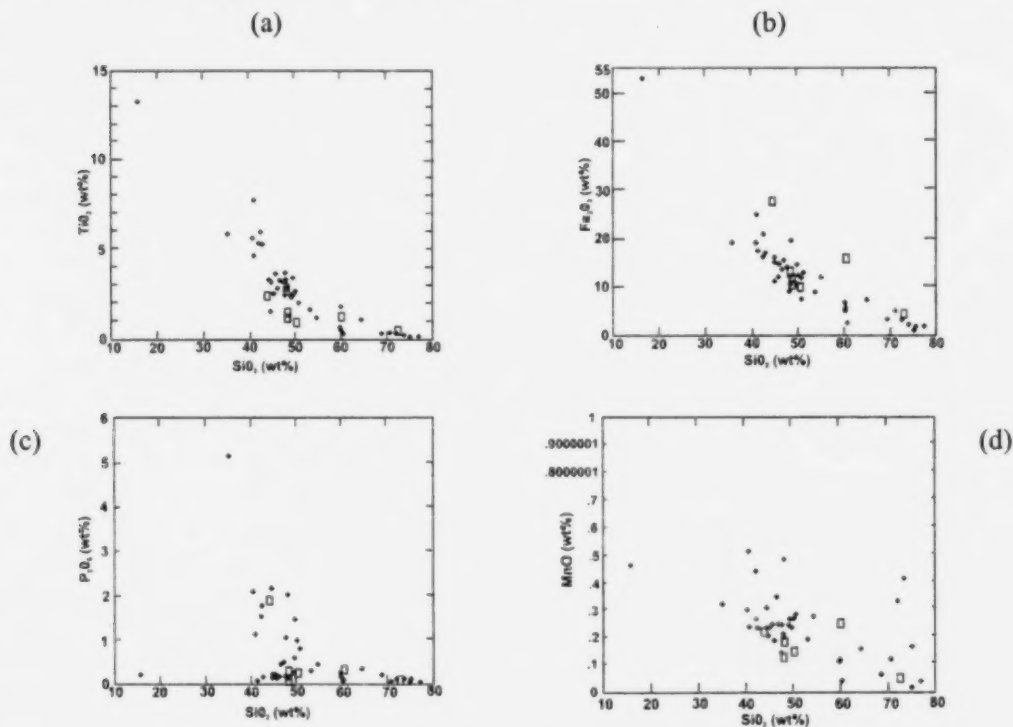


Figure 15. Harker variation diagrams: (a) TiO_2 , vs SiO_2 (b) $\text{Fe}_2\text{O}_3^{\text{T}}$ vs SiO_2 , (c) P_2O_5 , vs SiO_2 (d) MnO vs SiO_2 for (♦) Stewart Gabbro, Kings County, south-central New Brunswick and (□) reference rock types (bottom of Table 1, Appendix 7).

Fe₂O₃^T: The Fe₂O₃^T vs SiO₂ (Figure 15) demonstrates a negative correlation and above normal distribution. Iron oxide is significantly higher in rocks enriched in magnetite and ilmenite, gradually dropping off in more felsic compositions and in anorthosites. As expected, dioritic and granitic rocks show far less Fe₂O₃^T content accompanied by a significant increase in SiO₂.

MnO: Highest values are associated with pyroxene- and amphibole-rich rocks. MnO plotted against SiO₂ for dioritic and granitoid rocks do not show any pattern (Figure 15).

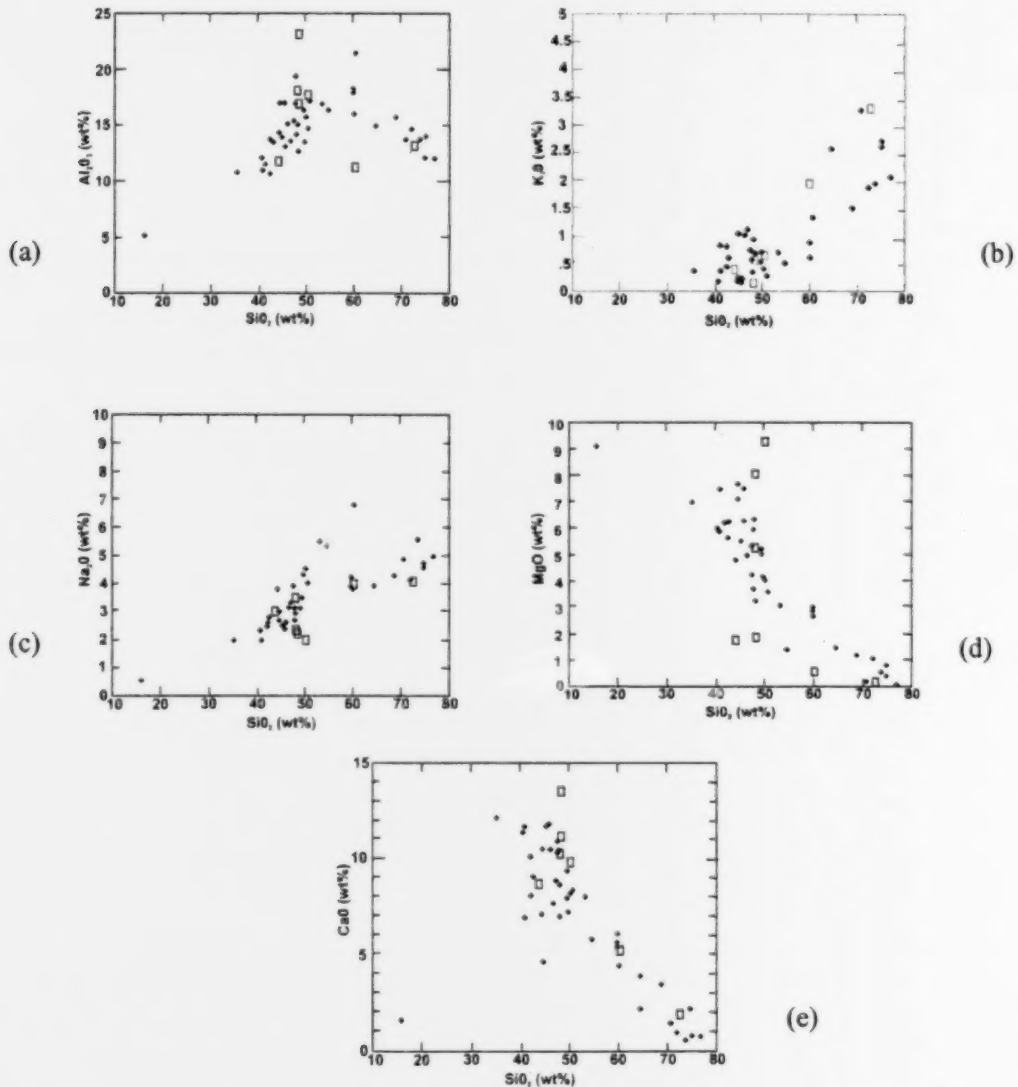


Figure 16. Harker variation diagrams: (a) Al₂O₃, vs SiO₂ (b) K₂O, vs SiO₂ (c) Na₂O, vs SiO₂ (d) MgO vs SiO₂ and (e) CaO vs SiO₂ for (♦) Stewart Gabbro, Kings County, south-central New Brunswick and (□) reference rock types (bottom of Table 1, Appendix 7).

MgO and CaO: The gabbroic rocks composed of mafic cumulates and intercumulates and their altered minerals are enriched in MgO. The plots of MgO and CaO vs SiO₂ (Figure 16) show curvilinear relationships with a negative correlation.

Na₂O and K₂O: Some gabbroic samples reporting high Na₂O values may reflect the alteration of calcic plagioclase exhibited in a few thin sections. The plots of Na₂O and K₂O vs SiO₂ (Figure 16) show positive correlation. Two trends are apparent in the Na₂O vs SiO₂ diagram.

P₂O₅: Phosphate content is directly proportional to the amount of apatite and appears to be anomalous in these rocks, particularly the gabbroic rocks. The plot of P₂O₅ vs SiO₂ (Figure 15) shows no significant pattern of distribution. However, plots of P₂O₅ vs TiO₂ and P₂O₅ vs Fe₂O₃^T (Figure 17) show a positive correlation.

L.O.I.: Loss on ignition considered to indicate the degree of alteration, varies from 0.0 % to 2.30 % with one sample as high as 7.63 %.

All the rocks of the gabbro body are quartz normative with most of the gabbroic rocks showing diopside and hypersthene normative (Table 3, Appendix 7). Dioritic and granitic rocks are significantly quartz normative. The gabbroic rocks are ilmenite, sphene and rarely rutile normative. The excess iron oxide appears as hematite normative. The Cumberlandite sample is the only one showing normative olivine.

AFM plots: Figure 18(a) shows an AFM (Na₂O+K₂O, FeO^T, MgO) ternary plot (Irvine and Baragar 1971) for rocks of the Stewarton Gabbro and reference type suites [Carmichael et. al. 1974; Allard 1976 and Nockolds 1978 (bottom of Table 1, Appendix 7)]. The Stewarton gabbroic rocks plot in the tholeiitic field whereas related dioritic and granitic rocks lie near the FeO^T-Na₂O+K₂O trend in the calc-alkaline field. A possible explanation for this distribution is that dioritic and hybridized rocks may have developed from the mixing of a later, high level granitic magma in contrast to being differentiated from an earlier, deeper source of basaltic tholeiitic magma the root source of anorthositic and gabbroic rocks. This feature can be discerned in the Harker variation diagrams displaying a bimodal distribution rather than a linear trend typical of differentiation from a single magma source.

From the AFM plot, it appears mafic rocks of the Stewarton Gabbro show a differentiation trend similar to that of the Skaergaard Intrusion in eastern Greenland (Carmichael et. al. 1974). Both intrusive bodies are low potassic tholeiites.

Trace elements: Trace elements and rare-earth elements for rocks of the Stewarton Gabbro are presented in Table 2 (Appendix 7). The distribution of trace elements indicate that all the rocks are depleted in copper (Cu), lead (Pb), zinc (Zn) and cobalt (Co). The Cumberlandite sample yielded very high concentrations of V (2698 ppm).

V, Ni, Cr, Ba, and Sr: Variation plot of V vs TiO₂ and (Figures 17) shows positive correlation and the distribution of vanadium suggests that rocks containing ilmenomagnetite are vanadiferous. Binary plots with Ni (Figure 19) show positive correlations with MgO and SiO₂, which is considered a good indicator for the fractionation of olivine.

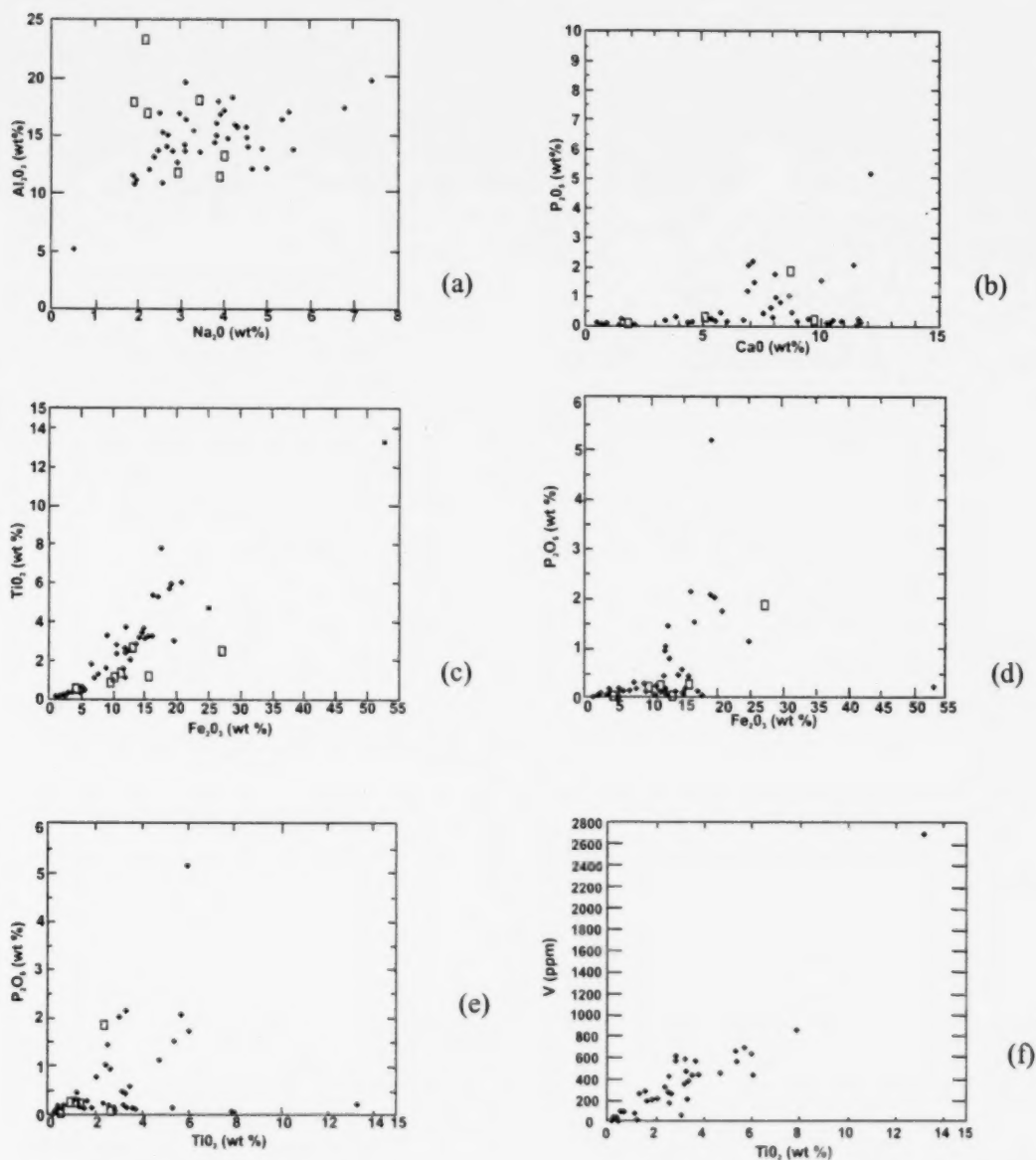


Figure 17. Variation diagrams: (a) Na_2O vs Al_2O_3 , (b) CaO vs P_2O_5 , (c) $Fe_2O_3^T$ vs TiO_2 , (d) $Fe_2O_3^T$ vs P_2O_5 , (e) TiO_2 vs P_2O_5 , and (f) TiO_2 vs V for (♦) Stewart Gabbro, Kings County, south-central New Brunswick and (□) reference rock types (bottom of Table 1, Appendix 7).

Cr also shows positive correlation with MgO and SiO_2 (Figure 19) in a Harker plot, diagnostic of enrichment during olivine fractionation and depletion during later differentiation of the magma.

The plot of Ba vs SiO_2 (Figure 20) shows a positive correlation up to 75 % silica, after which barium abundance drops off significantly. The Sr vs SiO_2 plot (Figure 20) shows a general

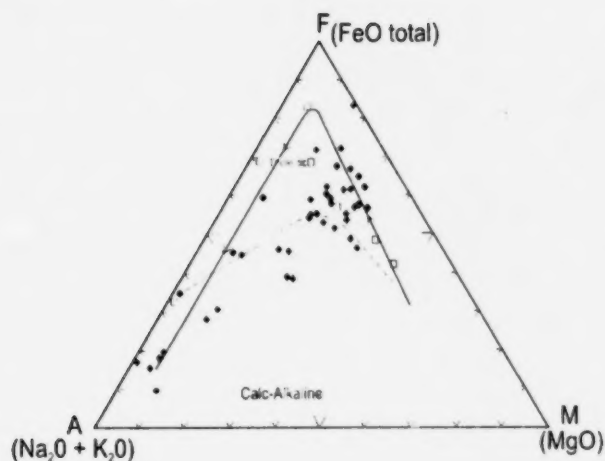


Figure 18a. AFM ternary plot of selected Stewarton Gabbro (♦) in relation to the boundary between tholeiitic and calc-alkaline compositional fields (Irvine and Baragar 1970). Also shown are reference rock types (□, listed at the bottom of Table 1, Appendix 7) from the Skaergaard Intrusion in eastern Greenland (Carmichael Turner and Verhoogan 1974).

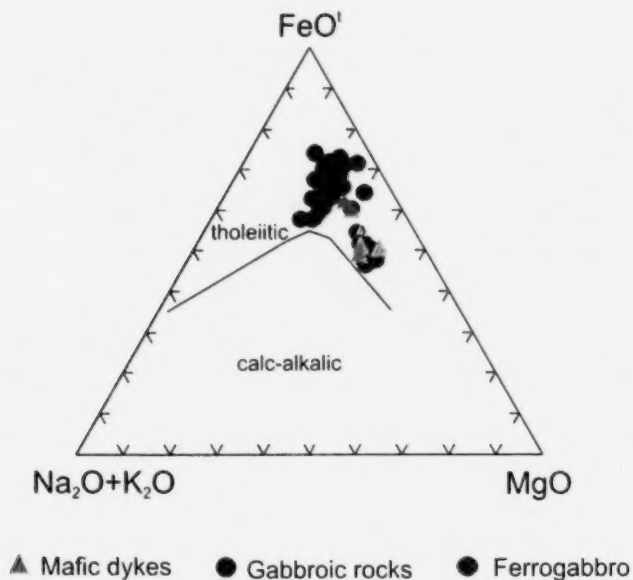


Figure 18b. AFM ternary diagram showing the boundary between tholeiitic and calc-alkaline compositional fields (Irvine and Baragar 1971) for selected rocks from the Lower Coverdale Gabbro (after Barr et al. 2002).

Enrichment of barium and strontium, especially, in gabbroic rocks indicates fractional crystallization of plagioclase and possibly amphibole as a differentiation mechanism in the igneous stratigraphy of the Stewarton Gabbro. This is particularly evident in the cumulus and intercumulus phases of plagioclase and amphibole (if primary) as these minerals are compatible at the upper levels of intrusion (Wilson, 1995). Both elements increase in abundance until a silica value of about 46 % and with a further increase in silica they are rapidly depleted (Figure 19).

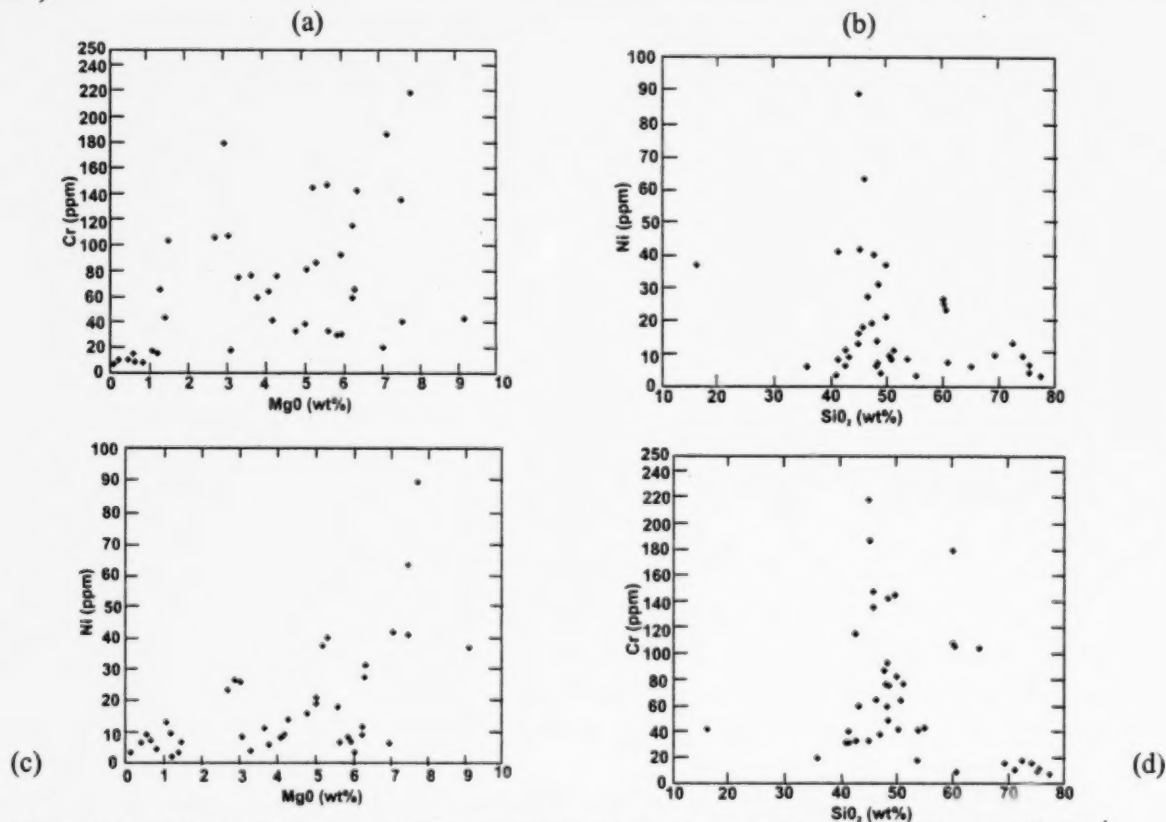


Figure 19. Variation diagrams: (a) SiO₂ vs Ni (b) SiO₂ vs Cr, and (c) MgO vs Ni, and (d) MgO vs Cr for the Stewarton Gabbro, Kings County, south-central New Brunswick.

Mineral chemistry: The chemical composition of mineral constituents from selected rock samples from the Stewarton Gabbro were analyzed at the University of New Brunswick utilizing SEM methods. Results for amphibole, clinopyroxene (cpx), ilmenite and magnetite are presented in Table 2a. The analysis suggests that the amphiboles are comparable to common hornblende to basaltic hornblende (Deer et al. 1967) with two samples showing enrichment in ferrous iron. Although the clinopyroxene falls into diopside-salite compositional field, optical properties suggest the presence of iron-rich augite. Ilmenites are manganiferous, with one sample yielding a high value of 7.66 % manganese and the magnetites are vanadiferous. Table 2c gives the chemical analyses for apatite minerals in gabbroic rock samples. The chemistry indicates they are fluorapatites with fluorine values up to 2.33 % accompanied by low values of MnO. The color of the apatite depending on its MnO content is light grey (MnO rich) to colorless.

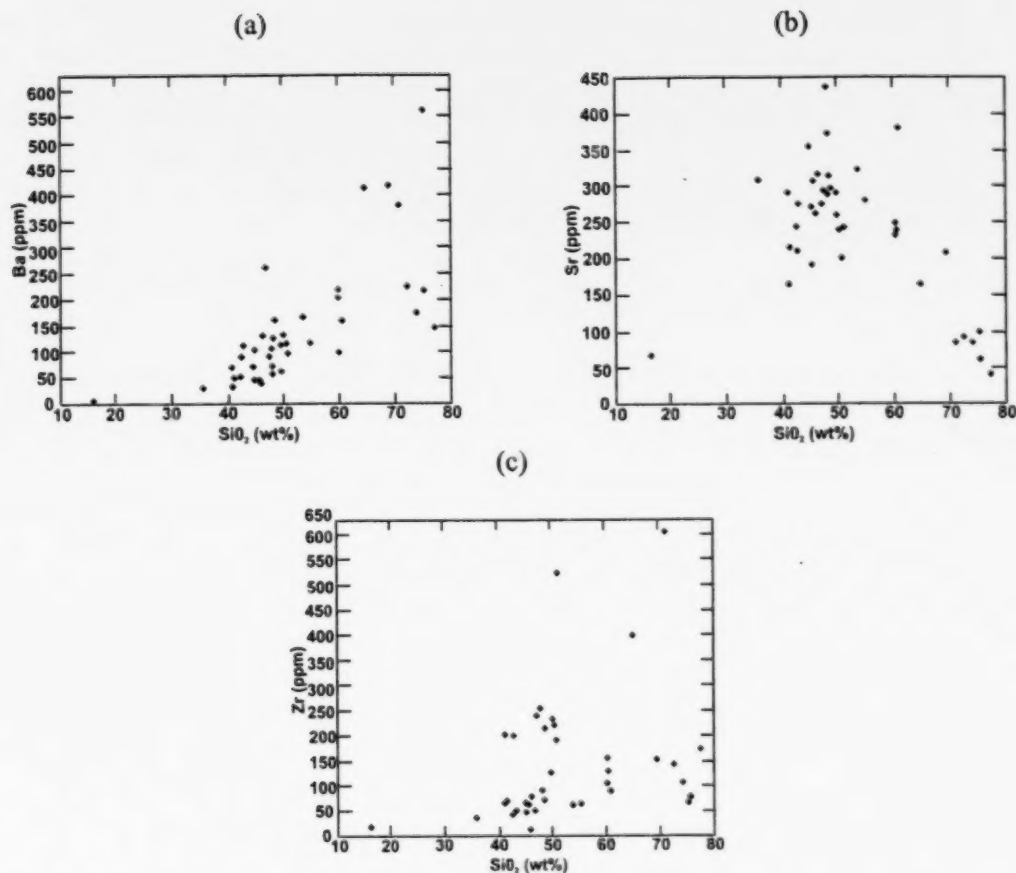


Figure 20. Variation diagrams: (a) SiO₂ vs Ba, (b) SiO₂ vs Sr, and (c) SiO₂ vs Zr for the Stewart Gabbro, Kings County, south-central New Brunswick.

Table 2b presents chemical analyses of the mineral constituents for the cumberlandite. Although olivine is slightly enriched in MgO (composition of Fo₆₇), Ni and Cr are rather low due to low MnO content (Deer et al. 1967). Olivine displays alteration rims, embayments and enclaves of kaersutite, the composition of which is included in the Table 2b. Coexisting and slightly altered plagioclase has a composition of An₄₇. Ilmenite shows an above normal value of 4.02 % of MgO, and magnetite is vanadiferous with the core areas of grains enriched compared to periphery.

Geophysics

The Stewart Gabbro displays well-defined total field and vertical gradient aeromagnetic anomalies (GSC 1990) in contrast to the host volcanic and sedimentary rocks. Magnetic susceptibility measurements were made on several gabbroic rock exposures returning a mean value of 0.07674 S.I. units as a representative value. However, individual values show a wide variation with a standard deviation of 0.029021 S.I. units. Magnetic and available gravity data were combined to construct a geophysical model for the Stewart gabbro body.

Table 2a. SEM analysis for minerals of selected gabbro samples from the Stewarton Gabbro, Kings County, south central New Brunswick (n=number of sampling points/grain; for location see Figure 2 and Map Plate 2000-30).

Sample	Amphibole				Cpx	Ilmenite				Magnetite	
	1B	8	9	23		1B	8	9	23	8	9
SiO ₂	46.73	45.14	48.6	44.66	52.40	0.01	0.00	0.36	0.02	0.04	0.01
TiO ₂	0.60	2.14	0.79	1.85	0.18	50.64	50.3	50.91	51.82	0.29	0.04
Al ₂ O ₃	5.79	9.33	6.92	8.24	1.11	0.02	0.00	0.16	0.02	0.37	0.07
Cr ₂ O ₃	0.03	0.03	0.03	0.03	0.03	0.03	0.06	0.03	0.02	0.35	0.22
FeO	24.39	14.07	14.9	21.22	7.95	45.88	48.8	39.22	45.66	88.42	88.97
Fe ₂ O ₃	-	-	-	-	-	-	-	-	-	-	-
MnO	0.42	0.19	0.49	0.36	0.22	2.98	1.16	7.66	2.84	0.03	0.02
MgO	7.53	13.17	14.0	9.37	14.02	0.04	0.06	0.06	0.04	0.03	0.00
CaO	11.42	11.71	11.0	10.78	23.70	0.01	0.01	0.32	0.05	0.17	0.00
Na ₂ O	0.79	1.88	0.81	1.22	0.18	-	-	-	-	-	-
K ₂ O	0.46	0.37	0.16	0.45	0.01	-	-	-	-	-	-
V ₂ O ₅	-	-	-	-	-	-	-	-	-	1.38	0.29
Nb ₂ O ₅	-	-	-	-	-	0.13	0.06	0.10	0.14	-	-
Total	98.16	98.02	97.6	98.18	99.80	99.74	100.0	98.82	100.6	91.08	89.62
Ave. n	6	9	6	5	4	5	6	5	5	5	5

Note: all samples numbers should be prefixed by "Ste"

Modeling defines the shape of the intrusion as a lopolith with an estimated thickness of over 3500 m near its central part south of East Scotch Settlement. One kilometre northeast, its estimated thickness decreases to about 850 m (Burke 2000, Appendix 6).

Structural and metamorphic features

A cursory examination of structural features suggest that the sedimentary and volcanic rocks of the East Scotch Settlement Formation in the map-area north of the Stewarton Gabbro were polydeformed and metamorphosed prior to the emplacement of the intrusion. Tight isoclinal folds locally observed in the wacke-slate sequence (O_{ESmc}) are reflected in a near vertical,

northeast trending axial planar, slaty cleavage. However, an outcrop of iron-formation in the mafic volcanic rocks of the formation, about 3.5 km east-northeast of Northrup's Corner, shows isoclinal folds with a horizontal to subhorizontal axial plane. Elsewhere, the mafic volcanic rocks are intensely fractured and sheared. A set of fracture cleavages, oriented parallel and subparallel to the slaty cleavage developed in pyritiferous slates of the Annidale Road area, may be associated with a second generation of folding. In addition to several episodes of folding, the rocks display structural features related to brittle/cataclastic deformation. In the area immediately south of the intrusive body, Silurian and Ordovician sedimentary rocks display poorly preserved bedding features.

Table 2b. SEM analysis for selected minerals in cumberlandite from the Stewarton Gabbro, Kings County, south-central New Brunswick (n=number of sampling points / grain; for location see "cum" on Figure 2 and Map Plate 2000-30).

Ste "cum"	Olivine	Kaersutite (amphibole*)	Plagioclase	Ilmenite	Magnetite	
					Core	Rim
SiO ₂	36.99	40.45	55.96	0.01	0.04	0.0
TiO ₂	0.01	3.54	0.08	52.37	15.39	0.39
Al ₂ O ₃	0.01	13.77	28.16	0.02	3.32	0.23
Cr ₂ O ₃	0.03	-	0.15	0.03	0.09	0.01
NiO	0.01	-	0.01	-	-	-
FeO	28.65	11.43	0.00	42.55	72.50	90.80
Fe ₂ O ₃	-	-	0.17	-	-	-
MnO	0.58	0.20	0.01	0.73	0.61	0.03
MgO	33.22	12.74	0.05	4.02	0.45	0.21
CaO	0.06	11.02	9.92	0.01	0.01	0.00
Na ₂ O	0.00	3.73	6.22	-	-	-
K ₂ O	0.00	0.52	0.15	-	-	-
V ₂ O ₃					1.92	0.07
	Fo ₆₇		An ₄₇			
Total	99.56	97.40	100.88	99.74	94.33	91.74
Ave. n	4	2	4	5	4	3

* alteration product of olivine

Table 2c. SEM analysis for apatite from gabbroic rock samples of the Stewarton Gabbro, Kings county, south-central New Brunswick (n= number of sampling points / grain; for location see Figure 2 and Map Plate 2000-30).

Ste #	8	9	11	23
CaO	54.06	54.13	53.72	54.06
P ₂ O ₅	40.89	42.02	42.30	42.22
MnO	0.01	0.03	0.05	0.01
Fe ₂ O ₃ [†]	0.11	0.26	0.08	0.11
F	2.33	1.94	2.33	1.40
Cl	0.05	0.23	0.37	0.05
Total	97.45	98.61	97.92	98.78
Ave. n	4	4	8	4

East Scotch Settlement Formation rocks have attained sub-greenschist to greenschist grade of metamorphism. Along the southern contact with the gabbro, sedimentary and volcanic rocks are hornfelsed to varying degrees.

In the Stewarton area three major northeast trending faults are recognized. Along the northern edge of the complex, a strike-slip fault occurs for the most part in the lower part of the mafic volcanic sequence associated with the East Scotch Settlement Formation. This fault apparently predates the gabbroic rocks of the complex. Immediately to the south is another strike-slip fault that trends almost parallel to the central axis of the intrusion. It is believed this structure was probably a major suture (lineament) along which Stewarton rocks intruded older Lower Palaeozoic strata in the region. A third major structural lineament occurring along the southern border of the complex splays into two separate structures in the Irish Settlement area. This fault has a dip-slip component as evidenced by slicken sides.

Although the pyroxene-amphibole gabbro is for the most part devoid of any penetrative and metamorphic fabric, a faint foliation defined by the subparallel orientation of plagioclase laths and a crude layering of mafic minerals is observed at some localities. Anorthositic rocks are usually foliated and show well developed rhythmic and cryptic layering and grading. The foliation commonly trends northeast, dipping at moderate to steep angles to the south.

Apart from the regional faults described above, the intrusion and the surrounding country-rocks are traversed by late north- and northwest-trending faults, shear zones and micro-faults. Near these features, rocks exhibit strong penetrative fabric (cataclastic), slicken sides, drag folds, vein displacement and annealed fractures along shears and micro-faults.

Mineralization

Titanium mineralization within the Stewarton Gabbro occurs in the form of an oxide (TiO_2), in silicate minerals, ilmenite, magnetite and ilmenomagnetite. The highest value of TiO_2 recorded in the gabbroic rocks is 7.82 % (Table 1, Appendix 7). A subcrop of cumberlandite, about 300 m east of Ewing Road (Figure 2) near the contact between orthopyroxene-olivine gabbro and anorthositic gabbro, yielded 13.24 % of TiO_2 . Since ilmenite is intimately associated with magnetite in solid solution it often occurs as ilmenomagnetite at higher temperatures of crystallization. At lower temperatures these two components separate when exsolution takes place. These oxides including titanium occur as: (1) discrete coarse ilmenite and magnetite interstitial grains as intercumulate, (2) finely disseminated rods and blebs in magnetite, pyroxene and amphibole, and (3) dense layers and disseminated grains in anorthositic gabbro. Some ilmenite is altered to sphene and rutile along shear zones during a late hydrothermal event.

Magnetite is vanadiferous (occasionally partially altered to hematite) in gabbroic rocks. Magnetite was once considered as a potential source of iron (Ells, 1907). A mineralized sample of cumberlandite contains 52.99wt% $\text{Fe}_2\text{O}_3^{\text{T}}$. Opaque oxides contain 1-2 % chalcopyrite and pyrite as irregular blebs and PGE elements were not detected in any mineralized sample(s).

Phosphate (P_2O_5), a constituent of apatite, is highly variable throughout the gabbroic rocks of the intrusion ranging from 0.01 to 5.17 % (Table 1, Appendix 7). Apatite is fluorapatite in composition and occurs as discrete subhedral to irregular, fine-to coarse-grained crystals often associated with but not restricted to, opaque oxides. It also occurs as tiny prismatic crystals in amphibole and as irregular grains in plagioclase.

In addition to titanium and apatite (phosphorous) mineralization, several base-metal sulphide and gold occurrences have been reported in adjacent rocks of the Annidale Group (McCutcheon and

Ruitenbergh, 1987; Ruitenbergh, A.A. et al., 1993). Some of these occurrences are shown on Map Plate 2000-30 (in pocket).

The Lower Coverdale Gabbro

Location and access

A subsurface gabbro intrusive body extending over 35–40 km² occurs about 2 km south of the City of Moncton near the Albert County community of Lower Coverdale in southeastern New Brunswick (Figure 1). The area is situated a few kilometers west of arterial Highway No. 114.

Previous work

The Lower Coverdale Gabbro was discovered over 80 years ago by New Brunswick Gas and Oilfields Limited (NBGO) test well near Mud Creek (Mud Creek # 52) during an exploration program for hydrocarbon resources (Figure 21). The Mud Creek hole intersected up to 128.05 m of Carboniferous strata and a 745.43 m sequence of what was considered "Precambrian rocks" (Kemp 1970) before terminating at a depth of 873.25 m.

In 1931, NBGO drilled a second hydrocarbon test well in the Lower Coverdale area. Lower Coverdale # 92 (Figure 21) intersected 108.23 m of Carboniferous sedimentary rock and 122.87 m of Pre-Carboniferous basement "granite and schists" (Kemp 1970). The hole was abandoned at a depth of 231.04 m. Drill cores from these NBGO test wells were examined and analyzed by Norman of the Geological Survey of Canada and officials of the New Brunswick Department of Lands and Mines in the late 1960s (Kemp 1970). It was concluded that the rocks underlying the Carboniferous formation(s) were mafic intrusives with potential for iron and titanium resources.

After nearly 40 years of little or no exploration activity in the area, the search for titanium-bearing rocks in Canada renewed interest in the Lower Coverdale property. The Killarney Oil and Gas Development Company Limited eventually established several mining claims in an area outlined by three prominent aeromagnetic anomalies. Killarney's work on the property included a ground magnetic survey and a four-hole drilling program accompanied by chemical assays of selected drill core sections. The company's drill holes were closely spaced and positioned on the flanks of a north-south trending magnetic anomaly. The recovery of almost 958.6 m of core revealed some interesting intersections of titanium, however, the overall widths and grades were not encouraging. Work on the property was concluded with the recommendation that three additional (305 m each) holes be put down to test several negative anomalies associated with areas displaying magnetic reversals.

The Lower Coverdale Gabbro has also been studied by Boyle of the Geological Survey of Canada (Boyle et al 1994; Boyle and Stirling 1994) who conducted studies to determine if these rocks were contributing to high and anomalous values of fluorine in the ground waters of the Moncton area.

In the early 1990s a rising market demand for titanium feedstock encouraged Noranda Mining and Exploration Inc. to stake the entire property covering the Lower Coverdale magnetic anomaly. A drill hole (LC 94-1) was put down in 1994 adjacent to the former

NBGO discovery hole at Mud Creek to confirm titanium values intersected by earlier drilling (Figure 21). This was followed by an aeromagnetic survey and a three hole, 2700 m drilling program in 1995 (Woods 1995).

The Geological Survey of Canada carried out detailed whole rock analysis and mineralogical studies along with geochronological work on drill core sections from the former Noranda drill holes, however, the results are yet to be released. In 2000 and 2001, Noranda deepened two of its 1995 holes (LC 95-2 and LC 95-3) to 968.65 m and 890.32. A new hole, LC 01-4 was completed to a depth of 825.5 m, encountering sporadic titanium mineralization [Moreton, personal communication 2001; (Figure 20)].

Other studies on the Lower Coverdale Gabbro include a Bachelor of Science Honors Thesis (MacHattie 1998) published in 1998 from Saint Francis Xavier University in Nova Scotia and the work of Barr et al. (2001 and 2002)

Present work

Present work conducted on the Lower Coverdale Gabbro includes: (1) a cursory examination of all former drill core including limited thin section studies on selected core sections, (2) core sample analysis and (3) a study of factors controlling the distribution of titanium and apatite mineralization in the intrusive body. The nature and character of the mineralization at Lower Coverdale are compared with similar rocks and mineral assemblages of the Stewarton Gabbro, near Sussex.

Geology of the Lower Coverdale Gabbro

The Lower Coverdale Gabbro covers approximately 35 to 40 km² coincident with a large positive aeromagnetic anomaly and is thought to intrude rocks of the Neoproterozoic to Cambrian Brookville terrane (Nickerson 1994 and White and Barr 1996). The following summarized geological description of the gabbro is based on drill hole data (*i.e.* lithological logs) provided by Noranda Mining and Exploration Inc. (Woods 1995; Ascough 1997 and Moreton 2001), an unpublished B.Sc. Honors Thesis by MacHattie (1998) and recent petrologic, lithogeochemical and mineralogical work by Barr et al. (2001 and 2002).

Drill hole data from the Lower Coverdale area is summarized in Table 3. Figure 22 provides a schematic distribution of lithologies encountered in five recent Noranda drill holes (Ascough 1997; Woods 1995; Moreton, personal communication 2001; and Barr, et. al. 2001 and 2002).

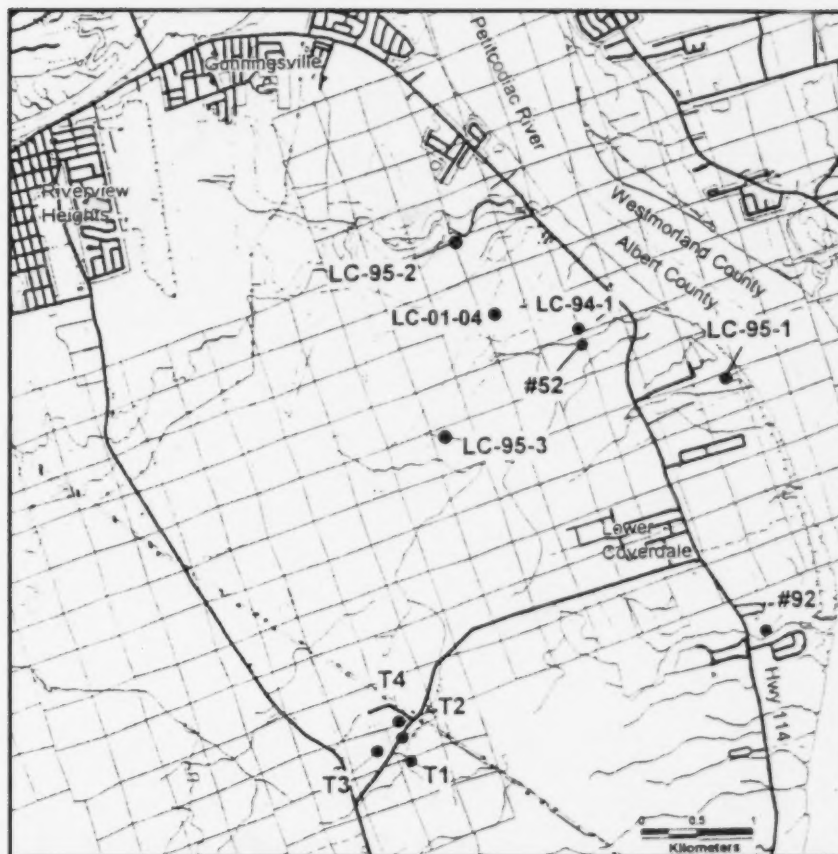


Figure 21. Location map of drilling activity near Lower Coverdale, Albert County, southeastern New Brunswick; (Holes # 52 and # 92-New Brunswick Gas and Oilfields Limited, 1919 and 1931; Holes T1 to T4-Killarney Oil and Gas Development Company Limited, 1969; Holes LC 94 to LC 01-Noranda Mining and Exploration Inc., 1994, 1995 and 2001). For details see Table 7, p.

Drill core and petrographic descriptions

Table 2 in Appendix 6 provides a descriptive petrographic summary of 24 drill core samples representing various key lithologies intersected during a recent drilling program by Noranda Mining and Exploration Inc. at Lower Coverdale. Two major rock assemblages are noted including one associated with Carboniferous sedimentary clastic rocks, and the other with mafic and felsic intrusives of the Lower Coverdale Gabbro.

Carboniferous sedimentary clastic rocks

Sedimentary clastic rocks intersected in Lower Coverdale drill holes comprise, primarily,

Table 3. Summary of drilling activity near Lower Coverdale, Albert County, southeastern New Brunswick.

DIAMOND DRILLING IN THE LOWER COVERDALE AREA SOUTHERN NEW BRUNSWICK					
COMPANY	DDH#	TOTAL DEPTH DRILLED IN METRES	OVERBURDEN THICKNESS IN METRES	WIDTH (THICKNESS) OF CARBONIFEROUS ROCKS OVER GABBRO IN METRES	YEAR OF DRILLING
New Brunswick Gas & Oil Fields Ltd.	Mud Creek 52	873.25	-	128.0	1919
	Lower Coverdale 92	231.04	-	108.2	1931
Killamey Oil & Gas Development Company Ltd.	T1	306.8	3.6	119.9	1970
	T2	310.2	3.0	120.2	1970
	T3	160.6	5.0	124.5	1970
	T4	182.8	3.6	118.4	1970
Noranda Mining and Exploration Inc.	LC 94-1	1206.4	12.2	139.7	1994
	LC 95-1	499.1	15.5	111.1	1995
	LC 95-2 ¹	557.6	11.0	194.6	1995
	LC 95-3 ²	437.4	5.8	114.2	1995
	LC 01-4	825.5	5.4	139.4	2001

Note: 1 The drill hole is extended to 968.65 m in 2001

2 The drill hole is extended to 890.32 m in 2001

fine-to coarse-grained Carboniferous clastics represented by Salisbury, Boss Point and Hopewell Cape formations (St. Peter, 2000). In holes LC 95-2 and LC 95-3, immediately below Hopewell Cape Formation, is a 5 to 10 metre-thick sequence of tan to buff, vuggy limestone of the Windsor Group (St. Peter, personal communication 2002). In almost all drill holes, a layer of sapprolitic gabbro underlies the Carboniferous strata. The Carboniferous rocks, immediately above this gabbro, carry placer type titanium mineralization.

Lower Coverdale mafic and felsic intrusive rocks

Barr et al. (2002) noted six main lithologies in the Lower Coverdale Gabbro. With the exception of metamorphic rocks occurring in one drill hole, these rock types include: anorthosite, interlayered ferrogabbro with anorthosite, ilmenite-bearing gabbro (ferrogabbro), gabbro, diabasic rock, and quartz monzodiorite and other felsic rocks.

Anorthosite: Anorthositic rocks exceed all other rock types in the Lower Coverdale Gabbro and occur in layers less than a metre to more than 40 m thick in the lower half of the intrusive body. They are medium-to coarse-grained and are composed almost entirely of plagioclase. The rock is light green to green and locally light brown, generally massive to fractured, and displays a slight foliation. In drill core these rocks are typically light to medium pink and salmon pink (Figure 23b), which is a function of intense shearing and alteration. Plagioclase is often altered to sericite, muscovite, and carbonate and is dusted with iron oxide and laumontite (Figure 5.1, Appendix 5).

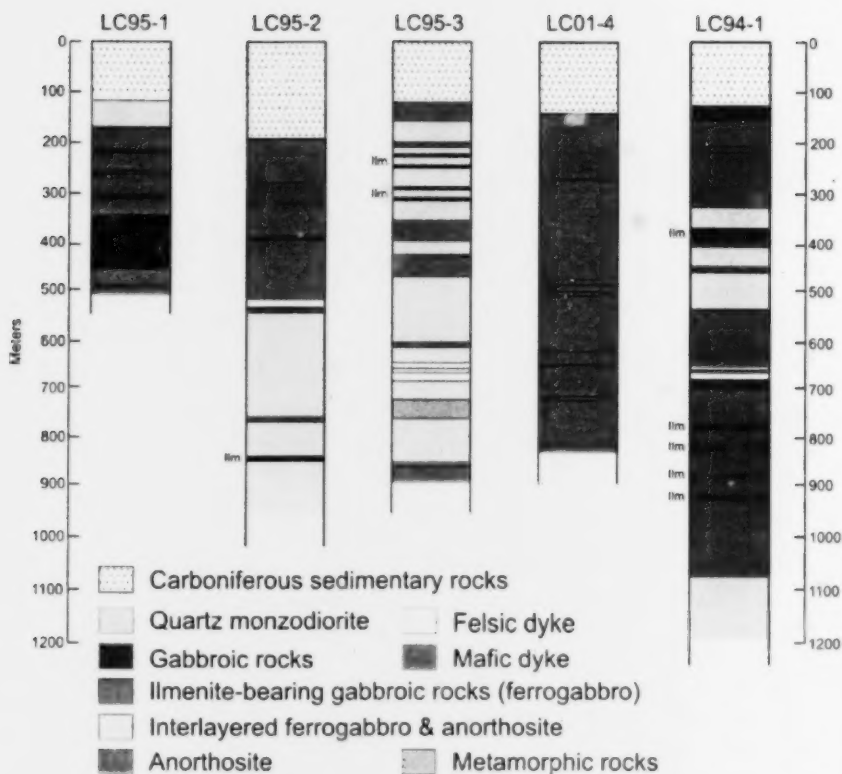
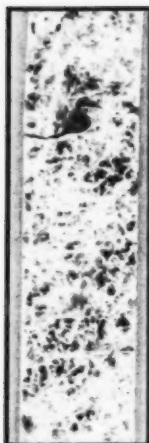


Figure 22. Distribution of lithologies in selected drill holes intersecting the Lower Coverdale Gabbro as per Noranda Mining and Exploration Inc. (after Barr et. al. 2002).

Locally, as the size of plagioclase crystals increase, the anorthositic gabbro grades to a pegmatitic texture (Figure 24).

Interlayered gabbro and anorthosite: Alternating layers of gabbroic and anorthosite rock are highly variable in thickness (between 10 to 200 m) and form a transitional zone of ferrogabbro and anorthosite. The interlayered anorthosite is very similar to the more massive variety described above. In some anorthositic sections, depletion of plagioclase is accompanied by an increase in ferromagnesium minerals in sufficient quantities to transform the rock from an anorthositic gabbro (Figure 25a) to a ferrogabbro (Figure 25b). The ferromagnesium layers are often laced with minor amounts (up to 6 %) of magnetite, ilmenite and apatite. The gabbroic rocks are medium to dark greenish grey to black, medium- to coarse-grained and display a crude layering.

Ilmenite-bearing gabbro (ferrogabbro): Ilmenite-bearing gabbro or ferrogabbro (Figures 5.2 and 5.3, Appendix 5) is a pale grey to dark greyish green, medium-to coarse-grained rock, composed of cumulates of plagioclase, pyroxene and amphibole and olivine (largely replaced by altered minerals). Most of the pyroxene, is pale green to bronze, variously altered to amphibole and chlorite. Some of the orthopyroxene (Figure 25c) is altered to orthoamphibole due to hydration (MacHattie 1998). Plagioclase crystals



(a)



(b)

Figure 23. Core samples of anorthosite from the Lower Coverdale Gabbro, Albert County, southeastern New Brunswick. (a) the least altered anorthosite, from LC 2001-2A @ 604 m (scale 1 cm = 4.5 cm) (b) intensely brecciated and altered anorthosite from LC 95-1 @ 221-234 m (Noranda Mining and Exploration Inc 1995 and 2001).

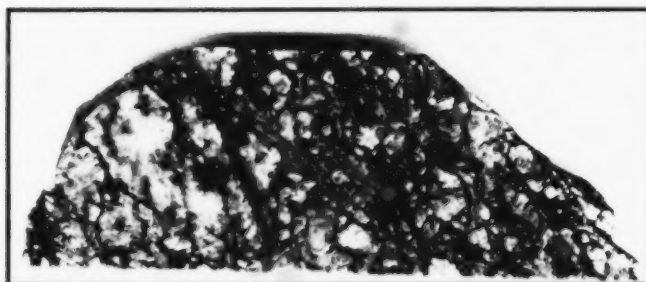


Figure 24. Pegmatitic anorthositic gabbro, from LC 94-1-1 @34 m, Lower Coverdale Gabbro, Albert County, southeastern New Brunswick. (Noranda Mining and Exploration Inc 1995) (scale 1 cm = 0.75 cm)

are also altered, as reflected in variegated shades of grey, green and purple, and where most altered are pink and red. Laumontite is ubiquitous among the common alteration minerals of plagioclase and occurs as irregular patches and veins (Figure 5.4, Appendix 5).

The ferrogabbro contains up to 30 % anorthositic gabbro in which much of the ilmenite and magnetite occurs as fine disseminations. In the massive to brecciated ferrogabbro, ilmenite is typically found as interstitial blebs and thin wispy layers (Figures 5.3 and 5.5, Appendix 5), and in nelsonite veins.

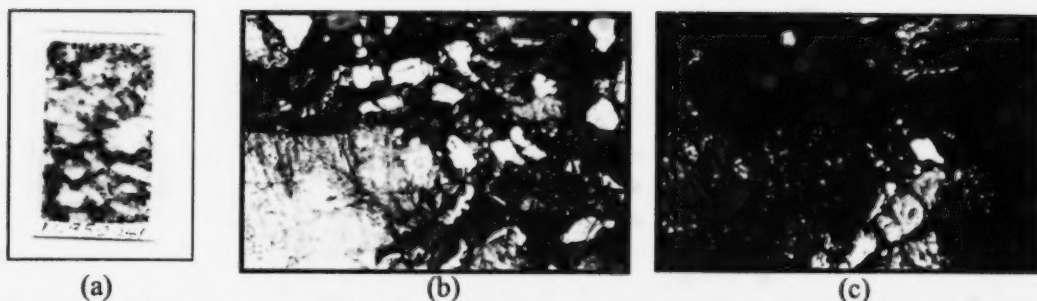


Figure 25a. Photomicrographs (b and c) of coarse-grained anorthositic gabbro from LC 95-2 @ 241 m, Lower Coverdale, Albert County, southeastern New Brunswick. Cumulates of plagioclase and clinopyroxene with a vein of apatite and sphene. (Noranda Mining and Exploration Inc. 1995) (a) thin section scale 1cm=1.25cm. (b) Plane polarized (c) Crossed polars. (scale 0.85 cm = 1mm).



Figure 25b. Photomicrographs (b and c) showing stringers of nelsonite in medium- to coarse-grained ilmenite-bearing ferrogabbro from LC 95-2 @ 357 m, Lower Coverdale, Albert County, southeastern New Brunswick. Note apatite crystals in the stringer (Noranda Mining and Exploration Inc. 1995) (a) thin section 1cm=1.25cm (b) Plane polarized (c) Crossed polars. (scale 0.85 cm = 1mm).

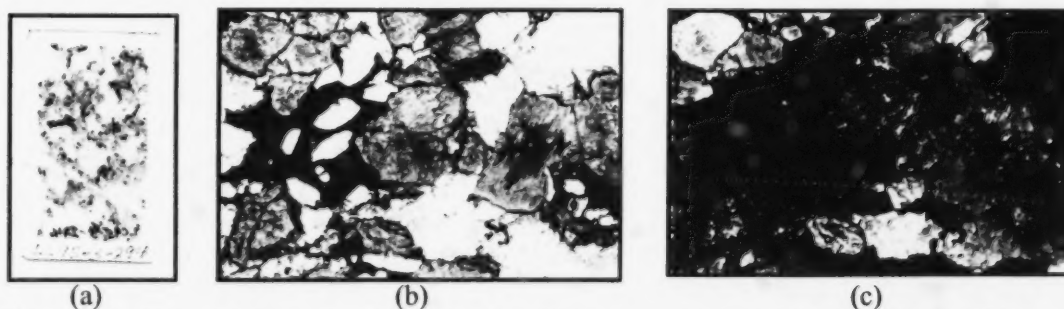


Figure 25c. Photomicrographs (b and c) of medium- to coarse-grained hypersthene gabbro from LC 95-3 @ 294 m, Lower Coverdale, Albert County, southeastern New Brunswick (Noranda Mining and Exploration Inc. 1995) (a) thin section 1cm=1.25 (b) Plane polarized (c) Crossed polars. (scale 0.85 cm = 1mm).

Gabbro: Minor gabbro, sheared and brecciated with little or no ilmenite mineralization is found in two of the Lower Coverdale drill holes. It is usually a medium-grained, light grey to buff coloured rock showing extensive quartz/carbonate and hematitic alteration. Cumulate minerals were probably plagioclase and clinopyroxene.

Diabasic rock: Diabasic rock displays a weak to strong foliation and occurs as dykes and sills in almost all the rock units of the intrusion. It commonly displays a sharp contact with adjacent chilled margins of widths up to a meter locally. It is characterized by limited ilmenite and apatite mineralization. Detailed work by MacHattie (1998) indicated that these rocks are finer-grained equivalents of gabbroic rocks.

Quartz monzodiorite and other felsic rocks: Over a 100 metre-thick section of weakly altered, coarse-to very coarse-grained, megacrystic quartz monzodiorite was intersected in one of the Lower Coverdale drill holes (LC 94-1) at a depth of 1196 m. This felsic rock is composed of over 60 % feldspar (mainly potash feldspar with minor plagioclase), up to 10 % quartz in a 25-30 % ferromagnesium groundmass, consisting of mainly chlorite and minor biotite and epidote. Except for local shearing, the rock is massive (Barr et al. 2001). The quartz monzodiorite has yielded U-Pb zircon ages of 391 +/- Ma (Barr et al. 2001) indicating that the Lower Coverdale gabbro is middle Devonian in age.

Felsic rocks occur as dykes of varying widths throughout the intrusion and are considered to be related to quartz monzodiorite, both mineralogically and temporally (Barr et al. 2002). In one drill hole (LC 95-2 @ 526 m), a highly fractured syenite to quartz syenite (Figure 5.8, Appendix 5) dyke was intersected.

Lithogeochemistry

Major element oxides: MacHattie (1998) and Barr et al. (2001; 2002) have carried out detailed geochemical studies on various lithologic units represented in the Lower Coverdale Gabbro. Harker variation diagrams (Figures 26, 29 and 30) of Barr et al. (2001 and 2002) show anorthosite samples plotting in a range between 50 to 58 % SiO₂, 5 to 8 % Na₂O and 20 to 27 % CaO. Typically these rocks are low in TiO₂ (0.1 %) and P₂O₅ (<0.05 %). Samples of anorthositic gabbro, a mix of anorthosite and ferrogabbro, show proportionately low values of silica and alkalis accompanied by elevated values of Fe₂O₃^T, TiO₂ and P₂O₅. SiO₂ values for ferrogabbro vary from 30 to 45 % and display a negative correlation with MgO, CaO, Fe₂O₃^T, TiO₂ and P₂O₅ in contrast to a positive correlation with alkalis and alumina. This chemical variation is reflected in the enrichment of ilmenite, magnetite and apatite in these rocks. A mineralized sample from a nelsonite vein intersected in a drill hole (LC 95-3) returned the following analysis (MacHattie 1998): SiO₂ 7.75 %, TiO₂ 19.24 %, Fe₂O₃ 27.62 %, P₂O₅ 14.72 % and CaO 22.21 %.

Figure 18b shows a ternary plot of Na₂O + K₂O, Fe₂O₃^T, and MgO for gabbro, ferrogabbro and mafic dykes of the Lower Coverdale Gabbro. The plot suggests that the mafic

intrusive rocks are tholeiitic. It also appears that the compositional ranges of these rocks is similar to that of the gabbroic rocks at Stewaron as displayed in Figure 18a.

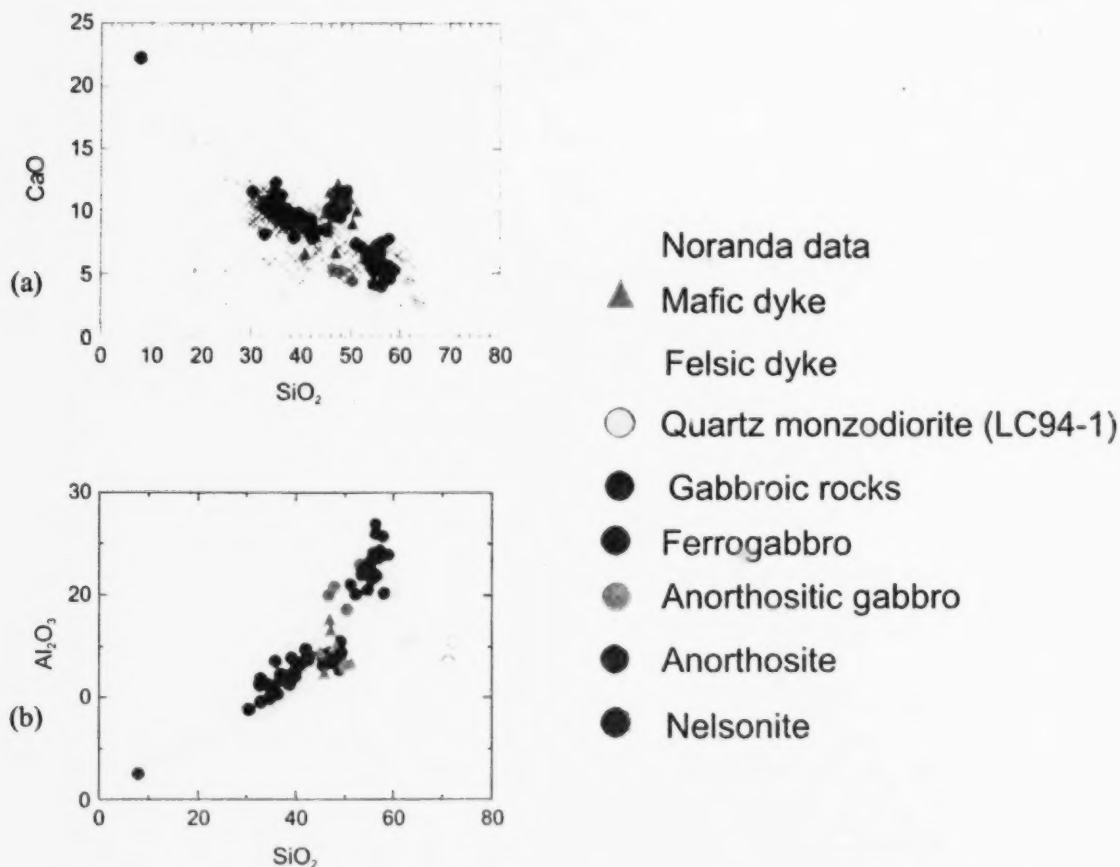


Figure 26. Harker variation diagrams for the Lower Coverdale Gabbro, Albert County, southeastern New Brunswick: (a) CaO vs SiO₂ (b) Al₂O₃ vs SiO₂ (after Barr et. al. 2002).

Samples of gabbro and diabasic rock show a similar distribution of major element oxides with respect to SiO₂ to those described above. The SiO₂ in the gabbro varies from 45 to 50 % and the TiO₂ content is less than 2 % with Fe₂O₃^T varying between 10 and 15 % (Figure 27). Trace elements such as Ni, Cr, and V show elevated values (MacHattie 1998; Barr et al. 2001 and 2002).

Mineral chemistry: Several polished thin sections of least altered mineral constituents from drill core were analysed by SEM at the University of New Brunswick. Analytical results and chemical compositions for orthopyroxene, clinopyroxene, amphibole, plagioclase, ilmenite, magnetite and apatite are presented in Table 4. The composition of orthopyroxene approaches that of ferrohypersthene (Deer et al. 1967), showing slightly lower SiO₂, Al₂O₃ and MgO and slightly higher FeO values. Figure 31 is the ternary

diagram depicting the composition of orthopyroxene that compares well with that obtained by Barr et al. (2002)

The Lower Coverdale clinopyroxene compositions obtained by Barr et al. (2001) from ferrogabbro, plot near subcalcic augite Figure 31(a). Clinopyroxenes from Lower

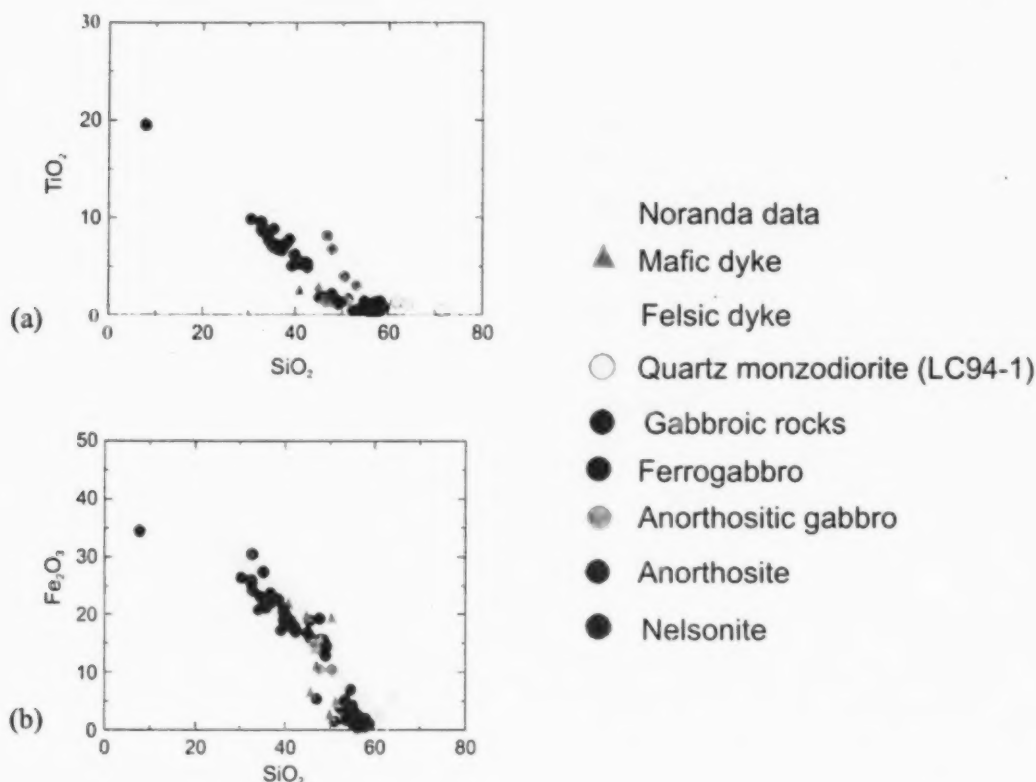


Figure 27. Harker variation diagrams for the Lower Coverdale Gabbro: (a) TiO_2 vs SiO_2 and (b) $\text{Fe}_2\text{O}_3^{\text{T}}$ vs SiO_2 (after Barr et. al. 2002).

Coverdale diabasic rocks plot in close proximity to diopside-salite composition (Figure 31b).

The composition of amphiboles from the Lower Coverdale Gabbro resembles that of actinolite (Deer et. al. 1967) showing minor variations in CaO and MgO . According to Barr et. al. (2001) the amphiboles have the composition of magnesium-rich anthophyllite. The plagioclase in the anorthositic and gabbroic rocks at Lower Coverdale is of andesine composition, whereas, that in the diabasic rocks is of labradorite composition (Barr et al. 2001).

Analysis of ilmenite and magnetite show that ilmenite is low in MnO and MgO with minor amounts of niobium and that the magnetite is vanadiferous.

Table 4. SEM analysis for selected minerals from gabbro core samples of the Lower Coverdale Gabbro, Albert County, southeastern New Brunswick (n = total number of sampling points / grain).

Sample	Orthopyroxene		Plagioclase LC-95-2-357	Clinopyroxene LC-95-3-328	Amphibole LC-95-3-150	Ilmenite Magnetite LC-94-1-415		Ilmenite Magnetite LC-95-2-357		Ilmenite Magnetite LC-95-3-330	
	KLOG-4-458	LC-95-2-357				Ilmenite	Magnetite	Ilmenite	Magnetite	Ilmenite	Magnetite
SiO ₂	56.05	57.32	58.75	50.52	53.19	0.01	0.02	0.01	0.09	0.01	0.01
TiO ₂	0.03	0.06	0.02	0.35	0.17	46.48	2.86	43.37	1.41	45.46	0.94
Al ₂ O ₃	1.68	2.16	25.75	3.53	3.24	0.01	0.04	0.00	0.13	0.02	0.17
Cr ₂ O ₃	0.00	0.01	0.02	0.01	0.11	0.06	0.16	0.03	0.03	0.06	0.15
FeO	17.56	16.77	-	10.53	12.70	50.97	87.22	53.67	89.85	51.25	90.30
Fe ₂ O ₃	-	-	0.06	-	-	-	-	-	-	-	-
MnO	0.38	0.41	0.00	0.27	0.27	0.39	0.01	0.53	0.01	0.45	0.03
MgO	22.65	22.43	0.00	12.16	16.21	0.27	0.03	0.07	0.03	0.33	0.03
CaO	0.36	0.66	7.73	21.92	12.51	0.02	0.02	0.00	0.05	0.02	0.06
Na ₂ O	0.10	0.26	7.29	0.57	0.28	-	-	-	-	-	-
K ₂ O	0.00-	0.08	0.12	0.05	0.05	-	-	-	-	-	-
V ₂ O ₅	-	-	-	-	-	-	0.70	-	0.37	-	0.50
Nb ₂ O ₅	-	-	99.86	-1	-	0.03	-	0.03	-	0.06	-
Total	98.78	100.16	3	4	2	98.24	91.06	97.71	91.97	97.66	92.19
Ave. of n	3	3	3	4	2	3	4	3	3	3	4

Apatite

Sample	LC-94-1-415	LC-95-2-357	LC-95-3-325
CaO	54.96	55.19	55.76
P ₂ O ₅	41.11	41.01	41.70
MnO	0.03	0.03	0.00
FeO	0.04	0.09	0.05
F	2.88	2.73	2.56
Cl	0.19	0.58	0.28
Total	99.13	99.43	100.34
Ave. of n	3	3	3

Apatite compositions at Lower Coverdale are indicative of fluorapatite low in MnO. The apatites are biaxial with a 2V of about 20°. A ternary plot of CaO, P₂O₅ and F[x10] for apatites at the Lower Coverdale and Stewart Complexes indicate they are of similar chemical composition (Figure 32).

Geophysics

Subsequent to aeromagnetic data collected by the Geological Survey of Canada (1956), Noranda mining and Exploration Inc. initiated additional aeromagnetic coverage over the Lower Coverdale intrusive in 1995. This survey was used to prepare a total field

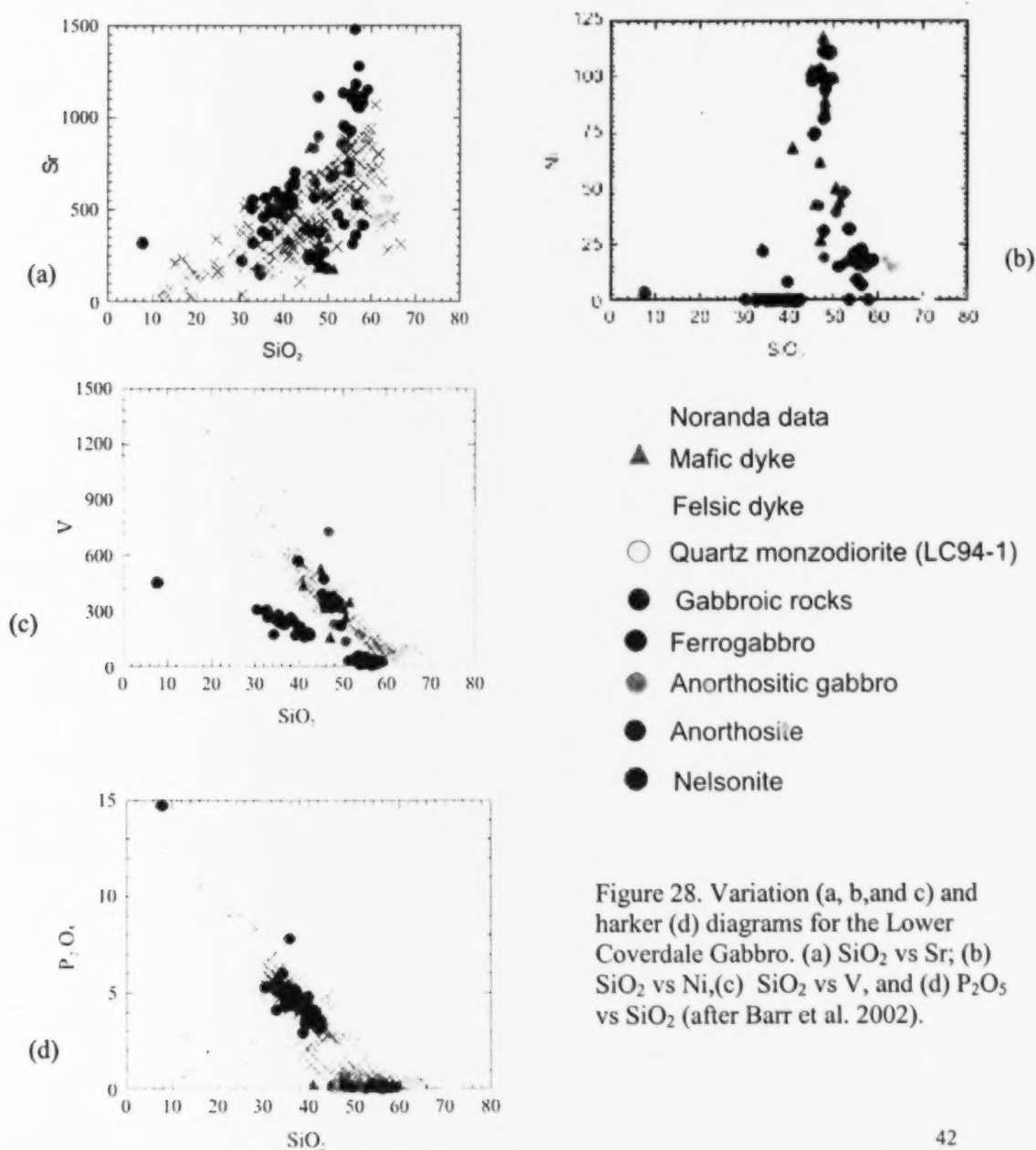


Figure 28. Variation (a, b, and c) and harker (d) diagrams for the Lower Coverdale Gabbro. (a) SiO₂ vs Sr; (b) SiO₂ vs Ni; (c) SiO₂ vs V, and (d) P₂O₅ vs SiO₂ (after Barr et al. 2002).

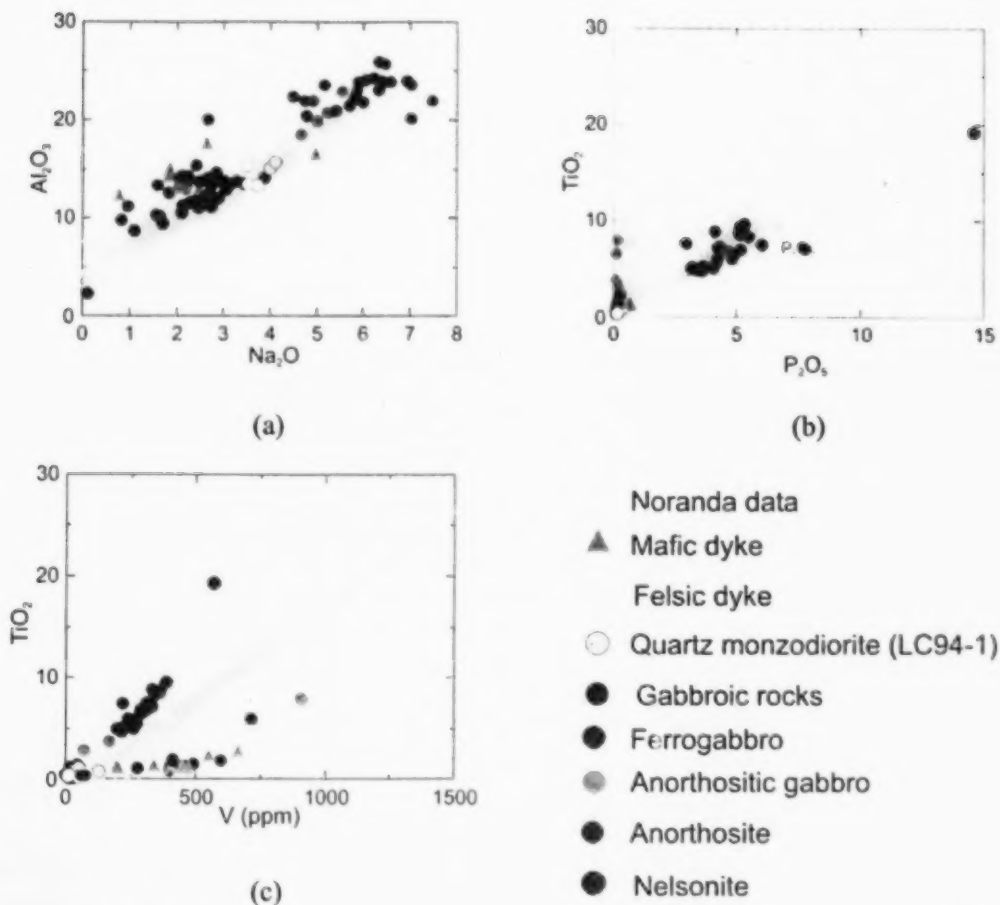


Figure 29. Variation diagrams for the Lower Coverdale Gabbro. (a) Na_2O vs Al_2O_3 , (b) P_2O_5 vs TiO_2 and (c) V vs TiO_2 (after Barr et al. 2002).

(magnetic) map for the area and a geophysical model (Burke 2000, Appendix 8). To compliment the modeling procedure several magnetic susceptibility measurements were taken on selected drill core samples. A mean value of 0.053592 S.I. units with a standard deviation of 0.051102 was determined as a representative value for the Lower Coverdale intrusive body. Gravity (Hassan 2000) and seismic reflection data available for the area were also incorporated into the model. It suggested that the Lower Coverdale intrusive is a lopolith, buried about 150 m below surface with thickness varying from 800 to 1000 m (Burke 2000, Appendix 8).

Mineralization

Following an examination of drill core and associated chemical analysis, it is obvious that the Lower Coverdale Gabbro is anomalous in ilmenite, magnetite, apatite and vanadium.

These minerals occur in concentrations several times higher than that normally associated with typical gabbro intrusive bodies.

Ilmenite ($\text{FeO} \cdot \text{TiO}_2$) occurs as intercumulate grains, blebs and rod-like disseminations in cumulates (usually along cleavages) and intercumulates of pyroxene and plagioclase.

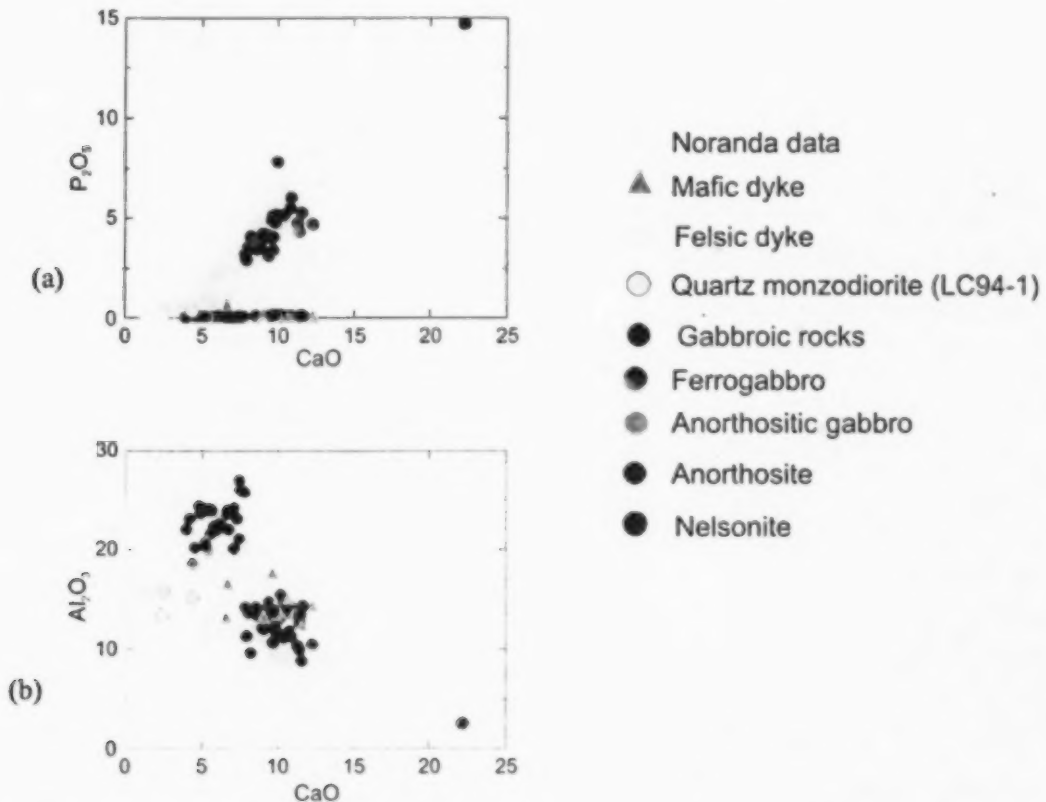


Figure 30. Harker variation diagrams for the Lower Coverdale Gabbro. a) CaO vs P_2O_5 and b) CaO vs Al_2O_3 (after Barr et. al. 2002).

Nelsonite (Figures 5.6 and 5.7, Appendix 5) consists of variable proportions of apatite and ilmenite with minor amounts of hematite and magnetite. Minor (1 to 2 %) base-metal sulphides, usually copper and even less significant amounts of pyrite and pyrrhotite, are associated with and in iron-bearing minerals (ilmenite and magnetite). Apatite [$\text{Ca}_3(\text{PO}_4)_3\text{F}$] is typically found as discrete subhedral to irregular grains and as long prismatic crystals interstitial to cumulates and also in amphibole, plagioclase and opaque oxides. They are particularly common in nelsonite veins (Figure 25b). Chemistry indicates that vanadium is associated with magnetite.

A schematic diagram showing the vertical distribution of various rock types as well as the main ilmenite-bearing layers in drill holes at Lower Coverdale presented in Figure 22 indicates high grade TiO_2 mineralization in thicknesses exceeding 2 m. According to

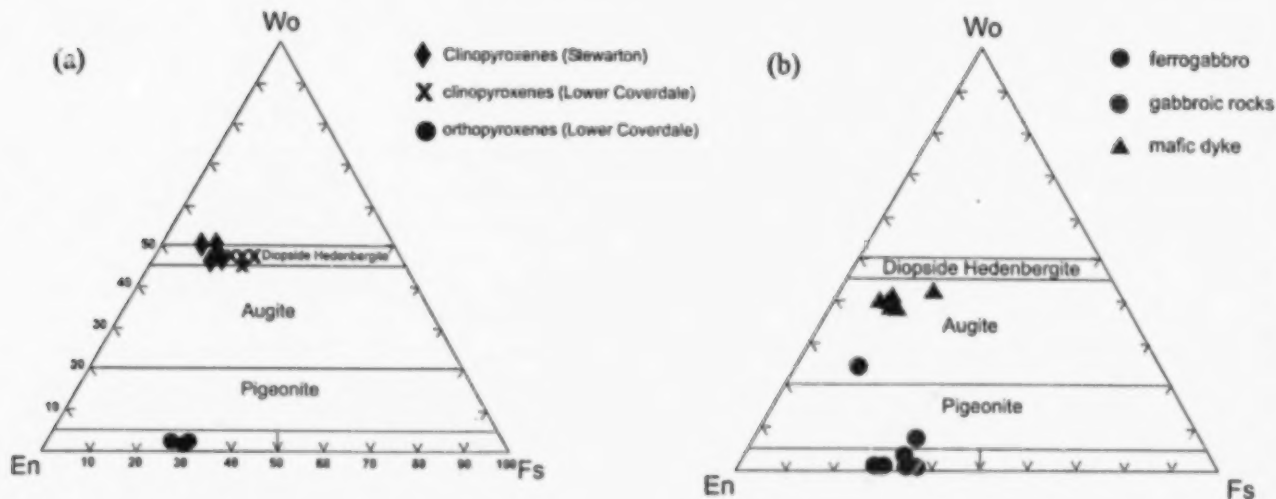


Figure 31. Ternary plots of Wo-En-Fs for pyroxenes (after Deer et al. 1967). Plot (a) shows clinopyroxenes from the Stewarton Gabbro; and clinopyroxenes and orthopyroxenes from the Lower Coverdale Gabbro. Plot (b) shows composition of pyroxenes from the Lower Coverdale Gabbro (after Barr et al 2002).

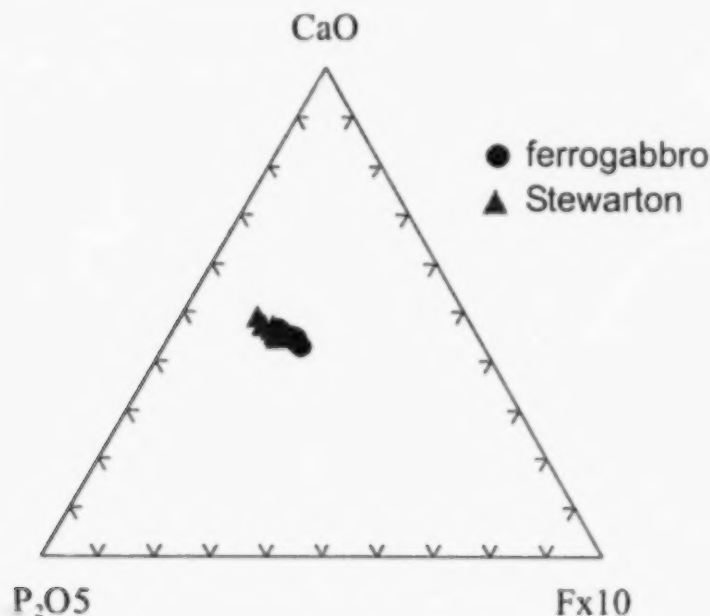


Figure 32. Ternary plot of CaO, P₂O₅ and F[*10] of apatite for gabbroic rocks from the Stewarton Gabbro and ferrogabbroic rocks from the Lower Coverdale Gabbro, southern New Brunswick (after Barr et al. 2002).

Woods (1995) some of the highest and most significant ilmenite intersections occur in drill hole LC 94-1 (Table 5).

In the drill hole LC 95-1, only low grade (up to 5 % TiO₂, interstitial ilmenite) and patchy ilmenite mineralization were encountered. In drill holes LC 95-2 and LC 95-3 (Table 6), the following intersections and grades were recorded.

In all drill holes, P₂O₅ content varies from less than 1 % to a high value of 11.9 %. Similarly, vanadium is variable, reaching a maximum of 1480 ppm. Drill hole LC 01-4 did not encounter any significant TiO₂ and P₂O₅ mineralization.

Table 5. TiO₂ intersections and grades in drill hole LC 94-1, near Lower Coverdale, Albert County, southeastern New Brunswick (Woods 1995).

Intersections (m) from to		Width of intersection (m)	Grade TiO ₂ %
395.7	400.6	4.9	23.1
436.9	440.7	3.8	22.4
504.0	516.0	12.0	16.65
587.0	715.1	128.1	11.6
884.5	888.6	4.1	22.4
926.0	932.0	6.0	17.1

Table 6. TiO₂ intersections and grade in drill holes LC 94-2 and 95-3, near Lower Coverdale, Albert County, southeastern New Brunswick (Ascough 1997).

Drill hole #	Drill hole intersection (m)		Width of intersection (m)	Grade TiO ₂ %
	from	to		
LC 95-2	204.3	293.9	89.6	6.91
	330.2	385.5	59.3	6.87
	396.6	527.5	130.9	7.29
	542.7	548.6	5.9	9.07
LC 95-3	330.0	352.7	22.7	11.60

Comparison between the Lower Coverdale and Stewarton Gabbros, southern New Brunswick

Table 7 summarizes and compares various features of the Lower Coverdale and Stewarton gabbro bodies. Both contain differentiated and fractionated potassic-poor tholeiites reflected in anorthositic and gabbroic rock suites. The two intrusive bodies are strikingly similar with respect to the following:

1. Variation diagrams with respect to SiO₂ versus major element oxides and trace elements of the Lower Coverdale Gabbro bear similarities with rock assemblages of the Stewarton intrusion.
2. Clinopyroxenes from the Lower Coverdale Gabbro plot in close proximity to those from Stewarton. The Stewarton clinopyroxenes are of diopside-salite composition.

3. A ternary plot of CaO , P_2O_5 and F [X10] for apatites from the Lower Coverdale and Stewarton gabbro indicate they are of similar chemical composition.

Although the chemistry and mineralogy of the two gabbros are similar the following differences are noted:

1. The Stewarton Gabbro clearly intrudes along a sutured (lineament) boundary between the Ordovician-Silurian rocks of the Annidale and Mascarene groups. By way of contrast, the country-rocks intruded by the Lower Coverdale Gabbro are unknown.

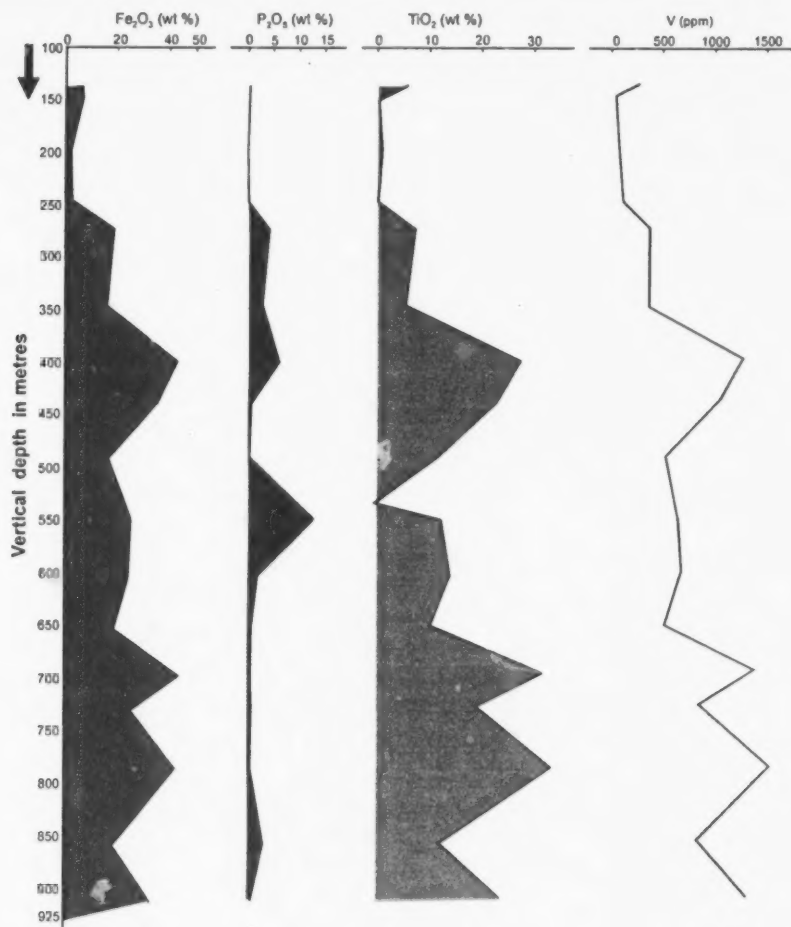


Figure 33. Plot demonstrating enrichment of Fe_2O_3^T , P_2O_5 , TiO_2 (wt %) and V (ppm) with increasing depth, in drill hole LC 94-1, near Lower Coverdale, Albert County, southeastern New Brunswick. There appears to be a strong correlation between Fe_2O_3^T , TiO_2 and V, whereas P_2O_5 is minimal at two intervals.

2. Diabasic rocks of both intrusive bodies are considered to be fine-grained equivalents of gabbro. In the Stewarton Gabbro, hybridized and partly assimilated felsic to intermediate

rocks, demonstrate a close temporal relationship to the diabasic rock (Figure 1.4; Appendix 1 and Figure 4.4; Appendix 4). In contrast, the Lower Coverdale Gabbro lack these assimilated and transitional rock assemblages. The only granitoid (quartz monzodiorite) and a few other felsic rocks encountered display a sharp to a chilled margin contact with anorthositic and gabbroic rocks.

Discussion

In general, mafic intrusion-hosted titanium-iron deposits as described by Gross (1996) are classified into two types: (1) a hemo-ilmenite and ilmenite hosted by Proterozoic anorthosite and (2) a titaniferous magnetite in gabbro and leuco-gabbro, (i.e. gabbro-anorthosite). Type 1 deposits are usually hosted by anorthosite massifs, similar to the Lac Tio deposit, located 42 km from Havre St. Pierre on the north shore of the St. Lawrence River, approximately 750 km northeast of Québec City, in the Province of Québec. Ilmenite deposits of this type rarely exceed 300 million tonnes of ore grading from 10 to 45 %, 32 to 45 % Fe and less than 0.2 % (2000 ppm) V. The ratio of Fe:Ti is generally about 2:1 with Fe:Cu, Cr, Mn, and Ni, each ranging from 0.05 to 0.2. Type 1 deposits typically contain minor apatite and sulphide mineralization.

Type 2 deposits typically host up to 1000 million tonnes of titanium ore, often containing 2 to 20 % TiO_2 and 20 to 40 % Fe, with Fe:Ti ratios ranging from 40:1 to 2:1 and more commonly around 5:1. Vanadium content is similar to that of Type 1 deposits, chromium is in trace amounts and P_2O_5 is as high as 7.1 %.

Considering their size, rock assemblages, mineralogy and the nature of mineralization, the Stewarton and Lower Coverdale gabbro bodies bear striking similarities to Type 2, iron-titanium-phosphate (FTP) deposits. Several genetic models for this type of deposit are summarized by MacHattie (1998). Although the spatial association of these deposits with anorthositic rocks has been recognized for a long time, a genetic relationship between the two is not clearly understood (Goldberg 1984). It is believed that FTP-rich rocks, co-magmatic with anorthosites, correspond to late-stage liquids evolved during anorthosite crystallization. According to Philpotts (1967), small amounts of olivine, orthopyroxene and clinopyroxene develop after the early crystallization of plagioclase. This resulted in the formation of troctolites and noritic and gabbroic anorthosites commonly interlayered with anorthosite. The early accumulation of large amounts of plagioclase could have caused enrichment of mafic components in the magma resulting in the formation of ferrogabbro and ferrodiorite. The composition and relatively small volumes of ferrogabbro and ferrodiorite relative to the abundance of anorthosite supports late-stage fractional crystallization from a tholeiitic-basaltic magma. The common occurrence of olivine in the Lower Coverdale and Stewarton gabbros indicate that these magmas probably had low oxygen fugacity, a factor suppressing the crystallization of magnetite and contributing to iron enrichment. This phenomenon is characteristic of anorthosite-gabbro intrusions in non-orogenic belts where oxygen partial pressure decreases with progressive crystallization as exemplified in the Skaergaard Intrusion in eastern Greenland (Lister 1966)].

Ferrogabbro and ferrodiorite formed in such a setting would commonly be associated with oxide-phosphate (apatite) rocks having compositions corresponding to maximum FTP enrichment in the anorthosite-mangerite suite (Philpotts 1967). Experimental evidence suggests that an immiscibility field exists between oxide-phosphate (apatite) rich liquid and a liquid of ferrodioritic composition (Philpotts 1967). Such a composition of liquid would have an oxide:apatite ratio of approximately 2:1

Table 7. Comparison between the gabbroic rocks of Lower Coverdale and Stewarton areas, southern New Brunswick.

COMPARISON BETWEEN STEWARTON COMPLEX AND LOWER COVERDALE GABBRO SOUTHERN NEW BRUNSWICK		
DESCRIPTION	STEWARTON COMPLEX	LOWER COVERDALE GABBRO
Major lithologies	Gabbro, anorthosite, diabase	Gabbro, ferrogabbro, anorthosite, diabase
Minor lithologies	Granitoid rocks, felsite and hybridized rocks	Granitoid rocks and felsite
Country rocks	Ordovician and Early Paleozoic volcanic and sedimentary rocks	Unknown in Brookville terrane
Age	By stratigraphic constraint - Lower Devonian	ca. 391 my - age determination on granitoid phase (U - Pb age in zircons)
Geophysical signature	Presence of strong aeromagnetic anomaly	Presence of strong aeromagnetic anomaly
Primary structure	Layering present; foliated	Layering present
Cumulus mineralogy	Plagioclase, clinopyroxene, orthopyroxene, olivine, $\pm$ amphibole (?); oxides of Fe, Ti, P	Plagioclase, clinopyroxene, orthopyroxene, olivine, $\pm$ amphibole (?); oxides of Fe, Ti, P
Deformational structures	Foliation, shearing and brecciation	Foliation, shearing and brecciation
Alteration	Saussuritization and sericitization of plagioclase; biotite and chlorite alteration of amphibole and pyroxene; talcose and serpentinization of olivine; kaersutite alteration around olivine; late hydrothermal alteration	Saussuritization and sericitization of plagioclase; chlorite and biotite alteration of amphibole and pyroxene; carbonate alteration; serpentine and talcose alteration
Veining	Epidote, zoisite, clinozoisite, prehnite and carbonate; locally sphene ($\pm$ leucosene) along shear zones	Chlorite, hematite, carbonate, sphene and laumontite, $\pm$ epidote group
Oxide mineralization	Magnetite, ilmenite, apatite; ilmenite locally altered to rutile sphene	Magnetite, hematite, ilmenite, apatite; ilmenite locally altered to leucosene
Apatite composition	Fluorapatite (2v ~ 20°)	Fluorapatite (2v ~ 20°)
Pyrite	Less than 1%	1 - 2%
Cu, Pb, Zn	Low concentrations (1 - 2 %)	Low concentrations (2 - 3%)
Vanadium	Anomalous values	Anomalous values

Thin concordant layers enriched with FTP (*i.e.* layers with disseminated iron-titanium oxide, and phosphate) and veins of nelsonite occur in the Lower Coverdale Complex. The ferrogabbro of the complex contains between 10 and 15 % interstitial ilmenite and apatite with up to 30 % ilmenite distributed in thin layers.

The mechanism for the formation of this type of mineralization is through the partitioning of highly charged density cations into a low-silica, phosphorous-enriched immiscible liquid from a ferrogabbro magma (Force 1991). The first stage in this process is the unmixing of tiny spherules of titanium-rich liquid from the parent magma (Figure 34). Following, is to form a titanium-rich interstitial liquid eventually crystallizing to form intercumulus grains of ilmenite and apatite. It is suggested that the FTP-rich liquid would have high-density and titanium droplets sink to the bottom of the magma chamber coming to rest on top of cumulates. The FTP-rich liquid sinks to deeper levels depending on the amount of poikilitic silicate crystallization that has taken place. These high temperature and low viscosity droplets, if abundant, coalesce sufficiently to permeate and fill the smallest selvages in uncemented silicate cumulates (Kolker 1982).

Such episodic crystallization would result in the formation of ilmenite (with or without magnetite) and apatite-rich layers depending on the availability of FTP-rich fluids relative to the crystallization of the silicate cumulates. Ilmenite and apatite layers devoid of any silicate cumulates would result in the formation of nelsonite. During the final stages of a magmatic event, coalesced FTP-rich, heavy and low viscous fluid descends through deformational and dilatent structures to the lower levels of the magma chamber usually,

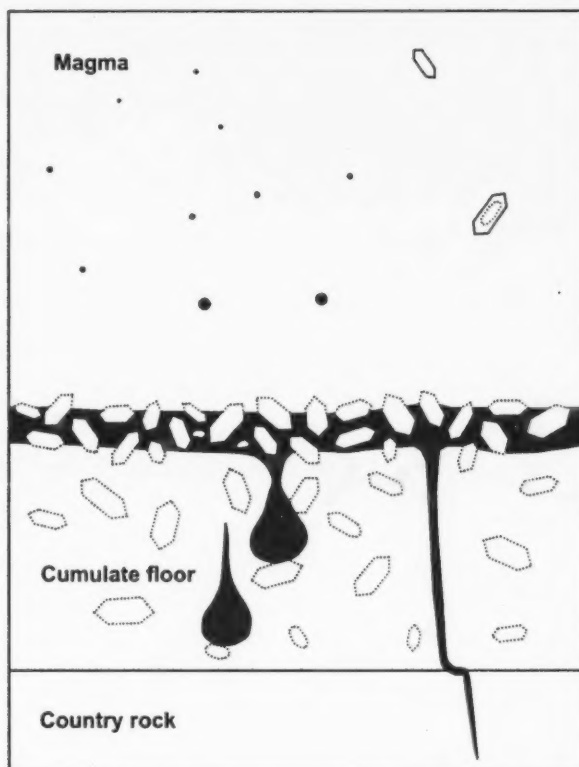


Figure 34. Diagram of a cumulate pile on a magma chamber floor overlain by a ferrodiorite- and ferrogabbro-enriched melt, illustrating the formation of magmatic ilmenite deposits (black denotes a dense iron-titanium-phosphate (FTP) immiscible liquid; the solid line prismatic crystals represent any cumulate solid, and the stippled prismatic crystals are separated by other silicates (modified from Force 1991).

comprised of anorthosite. This would then give rise to a discordant, bulbous massive Iron-titanium-phosphate deposit.

Conclusions

A comparison of geologic features and mineralization of two gabbroic intrusive bodies in southern New Brunswick reveal the following:

1. The Stewarton Gabbro, comprising anorthosite, gabbro, diorite and granitoid rocks, intrudes Silurian and older rocks along a suture (lineament) separating the Annidale

and Mascarene groups near Sussex in south-central New Brunswick. In southeastern New Brunswick, south of Moncton at Lower Coverdale, a subsurface pluton, composed of anorthosite, gabbro, monzodiorite and related felsic rocks lies in Neoproterozoic rocks associated with the Brookville Terrane. The true nature of the host-rock remains unknown. While parts of the Stewarton Gabbro outcrop on the surface, the Lower Coverdale Gabbro is overlain by a 180 metre-thick section of Carboniferous sedimentary rocks.

2. Both intrusive bodies are differentiated and fractionated from a low potassic tholeiitic basaltic magma. However, in the Stewarton area, a late, high level calc-alkaline granitoid intrusion may have occurred resulting in a complex assemblage of hybrid rocks.
3. The wide range of silica values, particularly in gabbroic rocks reflect the effects of differentiation and the intensity of alteration.
4. The Lower Coverdale Gabbro consists of a large buried mass of ferrogabbro characterised by anomalous values of titanium, phosphate and vanadium at depths exceeding 200 m from the roof of the intrusion. Although the gabbroic rocks at Stewarton also report anomalous titanium, phosphate and vanadium values, mineralized layers of ferrogabbro have not yet been confirmed. It is possible that such layers could occur in the subsurface.
5. Quartz monzodiorite at Lower Coverdale, has been dated at 391 $\pm$ Ma (middle Devonian). Rocks of the Stewarton Gabbro have not been dated, however, their intrusive relationship with host rocks of the Mascarene Group would indicate that they are at least post Middle Silurian in age.
6. Geophysical modeling from the available aeromagnetic and gravity data indicate that the Stewarton Gabbro has the form of a lopolith with an estimated thickness between 850 and 3500 m. Similar modeling studies of the Lower Coverdale Gabbro also suggests a lopolith with an estimated thickness between 800 and 1100 m.
7. The genetic model considered in this study appears to be consistent with the presence of an immiscibility field represented by thick layers of ferrogabbro enriched in iron, titanium and phosphate in an anorthosite-gabbro assemblage at Lower Coverdale. A similar scenario proposed for the Stewarton Gabbro remains untested, requiring exploration drilling.
8. A comparison of several key geologic features (i.e. rock type, mineralogy, texture, structure, age and the nature of mineralization) of the Stewarton Gabbro with those of the Lower Coverdale Gabbro, suggests that these are coeval lopoliths emplaced during the early Devonian. It is possible that a similar type and grade of titanium and related mineralization confirmed by drilling at Lower Coverdale may also exist at depth in the Stewarton area.

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APPENDIX 1

APPENDIX 1



1.1. A load-structure at the interface between fine- to medium-grained gabbro and fine- to medium-grained granitoid intrusion, south wall of the Jack Lake quarry, 1.5 km northeast of Stewarton, south-central New Brunswick.



1.4. Xenoliths of chilled and partially assimilated fine-grained gabbro in anastomosing granitoid rock; south wall of the Jack Lake quarry, 1.5 km northeast of Stewarton, south-central New Brunswick.



1.2. Layering in a granitoid intrusion cutting fine-grained gabbro, south wall of the Jack Lake quarry, 1.5 km east of Stewarton, south-central New Brunswick.



1.5 Orthogonally-orientated veins of granite cutting fine-grained diabasic gabbro, about 2 km east of Jack Lake, south-central New Brunswick.



1.3 Xenoliths of fine-grained gabbro rock in a granitoid intrusion, south wall of the Jack Lake quarry, 1.5 km east of Stewarton, south-central New Brunswick.



1.6: A large boulder from the Kincade Road area, displaying a xenolith of coarse-grained gabbro in granitoid rock, 3.8 km west of Stewarton, south-central New Brunswick.

APPENDIX 2

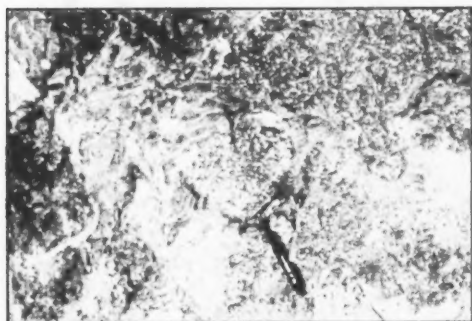
APPENDIX 2



2.1. Slump structures in fine-grained diabasic gabbro, about 300 m west of Jack Lake, south-central New Brunswick.



2.3. Angular to sub-rounded blocks of fine-grained porphyritic diabasic gabbro in an anastomosing quartzofeldspathic matrix cut by fine-to medium-grained granitoid rock; about 1.3 km east of Jack Lake, south-central New Brunswick.



2.2. Spheroidal structures in coarse-grained gabbro, surrounded by fine-grained diabasic gabbro, 300 m west of Jack Lake, south-central New Brunswick.



2.4. Flame-like granitoid structures intruding fine-grained diabasic gabbro, seen in a boulder in the Kincade Road area, 2.5 km east of Stewarton, south-central New Brunswick.

APPENDIX 2 (continued)



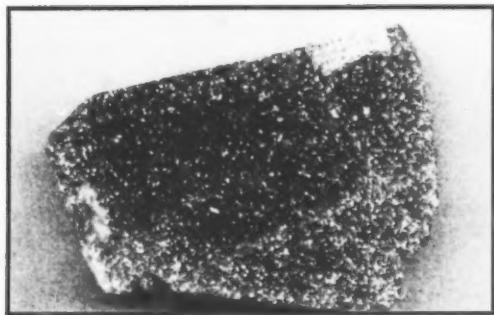
2.5. Transitional contact between fine-grained diabasic gabbro and coarse-grained gabbro (center of the photo) from the southwest corner of a blueberry field, about 300 m west of Jack Lake, south-central New Brunswick.



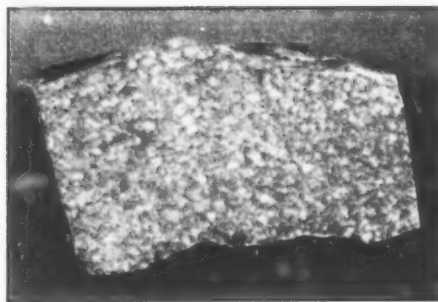
2.6. Coarse-grained gabbro cut by a light pink, medium-to fine-grained granite vein displaced along a shear plane, about 4.1 km east of Jack Lake, south-central New Brunswick.

APPENDIX 3

APPENDIX 3



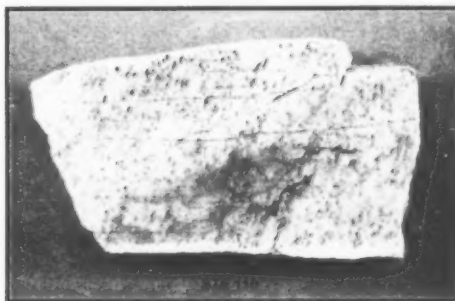
3.1. Fine-grained quartz diorite, situated on Henderson Brook, 100 m south of the Carter Road (9.3 km east of Stewarton, south-central New Brunswick). approx. scale: 1cm = 2 cm.



3.4. Quartz-phyric granite, situated about 1.2 km south of Northrup's Corner on the Annidale Road (8.1 km east of Stewarton, south-central New Brunswick). approx. scale: 1cm = 2.5cm.



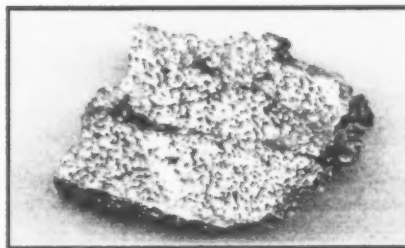
3.2. Medium-grained quartz monzonite, located about 600 m southeast of Northrup's Corner (8.6 km east of Stewarton, south-central New Brunswick). approx. scale: 1cm = 2 cm.



3.5. Cataclastically foliated felsite dyke, near microwave tower on East Scotch Mountain (5.7 km east of Stewarton, south-central New Brunswick). approx. scale: 1cm = 2.5 cm.



3.3. Cataclastically foliated granodiorite adjacent to Carter Road, 2 km east of Northrup's Corner (11.2 km east of Stewarton, south-central New Brunswick). approx. scale: 1cm = 2 cm.



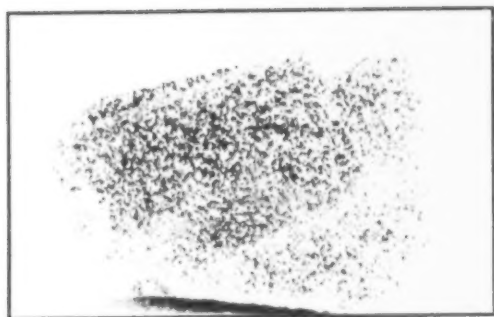
3.6. Sheared and hybridized granodiorite, north wall of the Jack Lake quarry, (1.6 km east of Stewarton, south-central New Brunswick). approx. scale: 1cm = 2 cm.

APPENDIX 3 Continued.

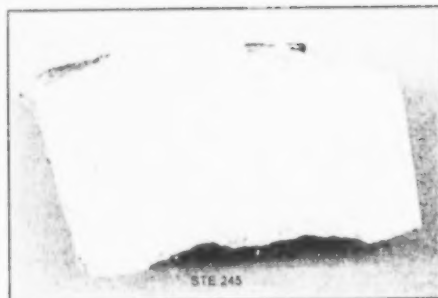


3.7. Fine- to medium-grained feldspar porphyry, south wall of the of the Jack Lake quarry (1.6 km east of Stewarton, south-central New Brunswick). approx. scale: 1cm = 3 cm.

APPENDIX 3



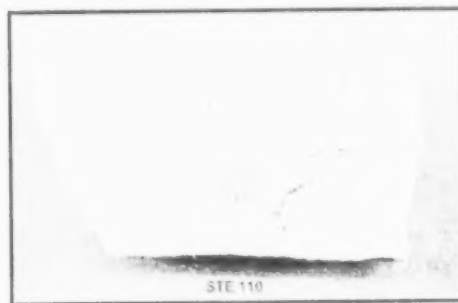
3.1. Fine-grained quartz diorite, situated on Henderson Brook, 100 m south of the Carter Road (9.3 km east of Stewarton, south-central New Brunswick). approx. scale: 1cm = 2 cm.



3.4. Quartz-phyric granite, situated about 1.2 km south of Northrup's Corner on the Annidale Road (8.1 km east of Stewarton, south-central New Brunswick). approx. scale: 1cm = 2.5cm.



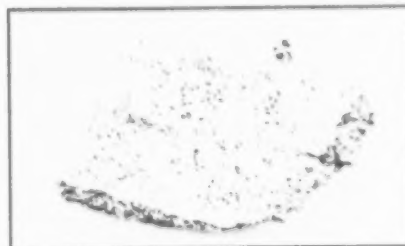
3.2. Medium-grained quartz monzonite, located about 600 m southeast of Northrup's Corner (8.6 km east of Stewarton, south-central New Brunswick). approx. scale: 1cm = 2 cm.



3.5. Cataclastically foliated felsite dyke, near microwave tower on East Scotch Mountain (5.7 km east of Stewarton, south-central New Brunswick). approx. scale: 1cm = 2.5 cm.



3.3. Cataclastically foliated granodiorite adjacent to Carter Road, 2 km east of Northrup's Corner (11.2 km east of Stewarton, south-central New Brunswick). approx. scale: 1cm = 2 cm.



3.6. Sheared and hybridized granodiorite, north wall of the Jack Lake quarry, (1.6 km east of Stewarton, south-central New Brunswick). approx. scale: 1cm = 2 cm.

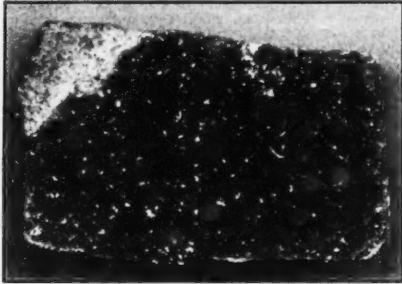
APPENDIX 3 Continued.



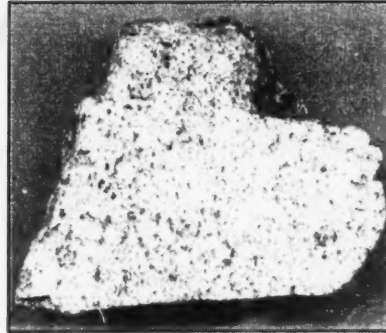
3.7. Fine- to medium-grained feldspar porphyry, south wall of the of the Jack Lake quarry (1.6 km east of Stewarton, south-central New Brunswick), approx. scale: 1cm = 3 cm.

APPENDIX 4

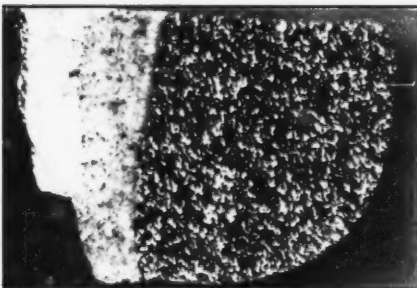
APPENDIX 4



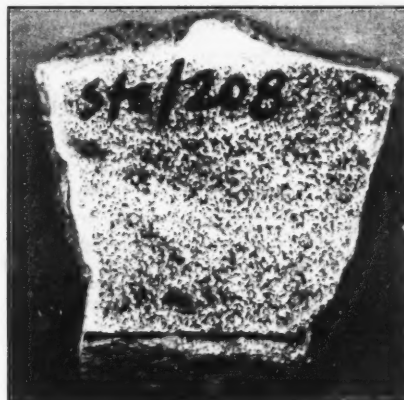
4.1. Fine- to medium-grained gabbro cut by pink granitoid rock about 3.2 km east of Stewarton, on Elm Brook, south-central New Brunswick.
approx. scale: 1 cm = 2 cm.



4.3. Medium-grained quartz diorite, about 7.7 km northeast of Stewarton on Joliff Brook, south-central New Brunswick. approx. scale: 1 cm = 2 cm.

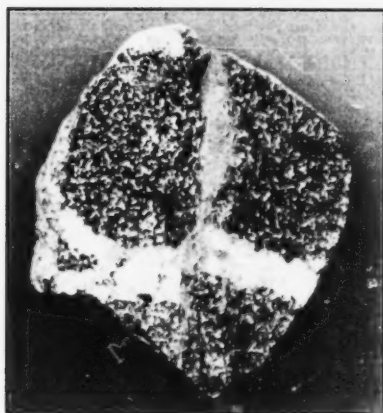


4.2. Foliated, medium- to coarse-grained gabbro cut by a feldspar-quartz porphyry, which is cut by coarse-grained granite, about 5 km northeast of Stewarton adjacent the Kincade Road, south-central New Brunswick.
approx. scale: 1 cm = 2 cm.



4.4. Hybridized irregular patches of gabbro in a dioritic matrix, located about 7.6 km northeast of Stewarton on Joliff Brook, south-central New Brunswick.
approx. scale: 1 cm = 2 cm.

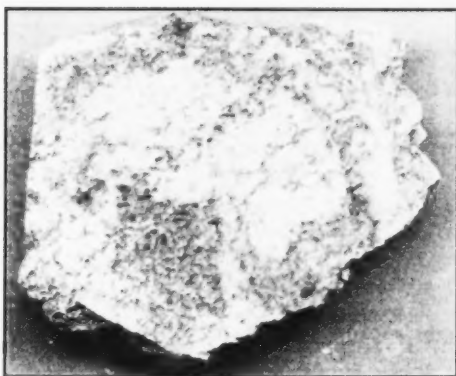
Appendix 4 continued



4.5. Gabbro intruded by a granitoid vein offset by a shear zone. The sheared zone is annealed by a chlorite-epidote vein associated with hydrothermal alteration. Located about 3.1 km east of Stewarton on Elm Brook, south-central New Brunswick. approx. scale: 1 cm = 2cm.



4.7. Mineralized sample of Cumberlandite (45-50% olivine, 45-50% magnetite-ilmenite and 10-15% plagioclase and clinopyroxene). Located about 4.4 km northeast of Stewarton, south-central New Brunswick). approx. scale: 1 cm = 2.4 cm.



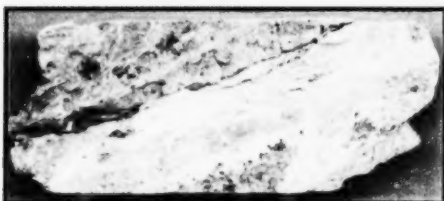
4.6. Alteration rind around patches of granodiorite. Notice light yellowish sericitic and argillaceous alteration material associated with a late hydrothermal event. Located about 8.7 km northeast of Stewarton, south-central New Brunswick. approx. scale: 1 cm = 1.5 cm.



4.8. Fine -to medium -grained feldspar-quartz porphyry. About 2.4 km northeast of Stewarton, south-central New Brunswick. approx. scale: 1 cm = 1.4 cm

APPENDIX 5

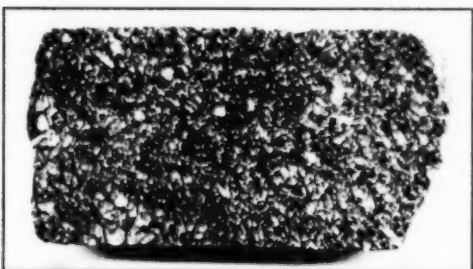
APPENDIX 5



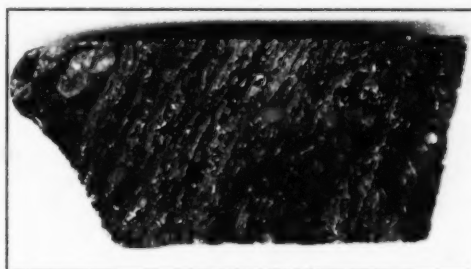
5.1. Pink to salmon pink, highly altered, laumontite-bearing anorthosite; from drill hole LC 95-3-20 @ 351.5 m., Lower Coverdale, southeastern New Brunswick. approx. scale: 1 cm = 2 cm.



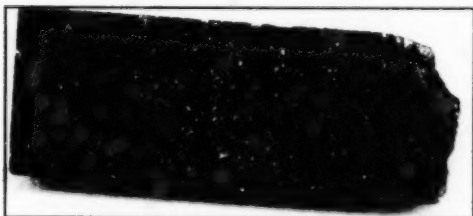
5.4 Dark greyish green to black, fine- to medium-grained gabbro displaying chlorite and laumontite alteration. The sample is mineralized with ilmenite and magnetite. Core from drill hole LC 95-3-6 @ 321.5 m., Lower Coverdale, southeastern New Brunswick. approx. scale: 1 cm = 1.6 cm.



5.2. Greyish green, fine-grained, strongly magnetic and altered ferrogabbro. Notice the disseminated ilmenite and magnetite mineralization. Core from drill hole LC 95-3-8 @ 328.0 m., Lower Coverdale, southeastern New Brunswick. approx scale: 1 cm = 1.7.



5.5. Steel grey to purplish grey, medium- to coarse-grained, distinctly banded gabbro displaying large laths of plagioclase. Mineralized streaks are ilmenite and magnetite. Core from drill hole LC 94-1-2 @ 396.8 m., Lower Coverdale, southeastern New Brunswick. approx. scale: 1 cm = 2 cm.



5.3 Dark grey to steel grey gabbro to ferrogabbro with disseminated ilmenite and magnetite mineralization; from drill hole LC 95-2-19 @ 357.0 m., Lower Coverdale, southeastern New Brunswick. approx. scale: 1 cm = 2 cm.

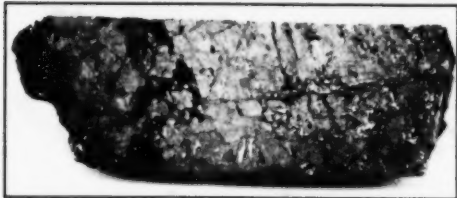


5.6 Dark steel grey, massive, ilmenite bearing gabbro mineralized with ilmenite and magnetite. Core from drill hole LC 94-1-4 @ 788.1 m., Lower Coverdale, southeastern New Brunswick. approx. scale: 1 cm = 2 cm.

APPENDIX 5 (continued)



5.7. Pinkish red to greyish red, fine-grained, intensely fractured syenite to quartz syenite. Fractures are infilled with carbonate. Core from drill hole LC 95-2-21 @ 526 m., Lower Coverdale, southeastern New Brunswick. approx. scale: 1 cm = 1.8 cm.



5.8.. Dark steel grey to purple grey, intensely fractured interlayered ferrogabbro and anorthosite, mineralized with ilmenite and magnetite. Notice chloritic alteration along fractures. Core from drill hole LC 94-1-3 @ 415.2 m., Lower Coverdale, southeastern New Brunswick. approx. scale: 1 cm = 1.6 cm.

APPENDIX 6

Table 6.1. Petrographic summary of rock types from the Stewarton Gabbro, Kings County, south-central New Brunswick.

Table 6.2. Petrography of selected drill core samples from the Lower Coverdale Gabbro, Albert County, southeastern New Brunswick.

Table 6.1. Petrographic summary of rock types from the Stewarton Gabbro, Kings County, south-central New Brunswick.

Ste #	Rock type	Main minerals (%)	Accessory minerals (%)	Alteration minerals	Texture and grain size (mm)	Vein and fracture filling
1A/99	Pyroxene – hornblende gabbro	pl (35-40), cpx (7-10), hbl (45-50)	apa (2-5), mag+ilm (10-12), py+chp (<1)	serp, tal, chl, epi, act, trem, bowl, id, seri	hypidiomorphic granular; 0.5-5.0	
1B/99	Gabbroic anorthosite	pl (80-85), hbl (10-15)	apa (2-5), ilm+mag (5-6)	bio, bowl, id, chl, seri	0.2-0.5	preh, epi- group, qtz, sph
1C/99	Pyroxene gabbro	pl (25-30), hbl (45-50), cpx (12-15), oliv (15-20)	apa (2-5), ilm+mag (7-10)	tal, chl, serp, act/trem, seri, bio, epi	foliated, sheared, poikilitic (pl in cpx); 3.0-4.5	
2/99	Gabbro	pl (45-50), cpx (5-10), hbl (40-45), bio/chl (10-15)	apa (2-3), ilm+mag (5-7)	chl, qtz, seri	poikilitic (pl in hbl) and inclusions of apa in hbl	
3A/99	Pyroxene – olivine gabbro	oli (35-40), pl (10-12), cpx (35-40), hbl (5-10), bio (5-6)	apa (<1), ilm+mag (3-4)	bio, chl, seri	cpx with inclusions of bio and apa; pl with inclusions of opaques	
3B/99	Diabase	pl (45-50), cpx (25-30), hbl (25-30)	apa (1-2), ilm+mag (5-7), py+chp (<1)	chl, seri, epi, preh, qtz	subophitic to diabasic, poikilitic; 0.1-0.5	epi, preh, qtz
4/99	Pyroxene – olivine gabbro	pl (65-70), hbl (10-15), oli (7-10), cpx (10-15)	apa (<1), ilm+mag (5-7)	serp, chl	slightly foliated	
5/99	Labradorite	cpx (75-80), pl (7-10), hbl (5-6), oliv (3-5)	ilm+mag (3-5)	chl, bio, serp	pegmatitic; 1.0-15.0	
6A/99	Pyroxene gabbro	pl (25-30), cpx (55-60)	apa (1-2), ilm+mag (5-7), py+chp (<1)	act/trem, serp/tal	subophitic to ophitic, 4.0-10.0	
6B/99	Pyroxene gabbro	cpx (50-60), pla (25-30), oliv (2-5), hbl (5-10), bio (5-6)	ilm+mag (3-5), apa (<1), chp+py (<0.5)	bowl, id, chl; reaction rim around opaques and cpx; opaques display worm and cauliflower-like structure; carbonate alteration in cpx and pl	poikilitic, 4.0-6.0	
6C/99	Pyroxene gabbro	pl (70-75), cpx (7-10), hbl (10-15), bio (5-10)	ilm+mag (7-10)	hbl, chl, bio	poikilitic; 0.5-2.0, patches of coarse grained pyroxenite and fine grained gabbro occur as xenoliths in anorthositic gabbro	
6E	Quartz-diorite	pl (65-70), amp/chl (5-6), qtz (30-35)	sph, epi (1-2)	chl	silicification and assimilation of diabase; (0.05-0.4)	quartz
6F1	Granite	pl (30-35), k-spar (30-35), qtz (25-30), chl+bio (1-2)	epi (<1), sph (<1)	seri, chl, hem	undulose extinction in qtz; granulation	epi+chl; qtz
6F-1	Granite	pl (30-35), k-spar (30-35), qtz (25-30), chl+bio (2-4)	epi (<1), sph (<1)	seri, chl, hem	Myrmekitic and graphic intergrowth between quartz and feldspar; bent pl twins	epi+chl; qtz
6G	Granodiorite	pl (25-30), k-spar (15-20), qtz (15-20), chl+bio (25-30)	epi (1-2), ilm (<1)	seri, qtz, hem	hypidiomorphic and minor myrmekitic texture; (0.1-0.2)	
6H	Granodiorite	pl (25-30), k-spar (15-20), qtz (15-20), chl+bio (25-30)	epi (1-2), ilm (<1)	seri, hem	cataclastic texture; (0.5 – 0.8)	
7/99	Hornblende quartz diorite	pl (45-50), hbl (15-20), bio (12-15), qtz (12-15)	ilm+mag (<1%), py (<1%)	epi group, chl	cataclastic, strong foliation; deformation lamellae in qtz	
8/99	Pyroxene gabbro	pl (45-50), cpx (10-15), hbl (15-20), oli (10-15)	apa (2-3), ilm+mag (7-10)	bowl, id, serp/tal, seri, chl	4.0-8.0	
9/99	Hornblende gabbro	pl (55-60), hbl (10-15), bio/chl (15-20), qtz (5-10)	apa (1-2), ilm+mag (2-3)	chl, seri	subporphyritic; matrix (0.5-1.0) phenocrysts 1-4	
10/99	Anorthositic gabbro	pl (45-50), cpx (45-50), oli (5-10), hbl (10-12)	apa (<1), ilm+mag (7-10), py+chp (<1)	bio, chl, epi group, seri, preh	myrmekitic, cauliflower-like intergrowth in cpx and pl in contact with opaques; 0.5-2.0	epi group, preh, chl
11/99	Anorthositic gabbro	pl (35-40), hbl (55-60)	apa (5-7), ilm+mag (3-5), rut (<1), sph (<1), py+chp (<1)	act/trem, serp/tal, chl, epi group, preh	original textures totally obliterated; apa is very coarse and sheared; 0.5-2.0	epi group, preh, chl sph

Abbreviation: apa, apatite; act, actinolite; bio, biotite; bowl, bowlingite; carb, carbonate; chl, chlorite; cpx, clinopyroxene; epi, epidote; hbl, hornblende; hem, hematite; id, iddingsite; ilm, ilmenite; kaer, kaersutite; mag, magnetite; oli, olivine; pl, plagioclase; preh, prehnite; py, pyrite; qtz, quartz; rut, rutile; seri, sericite; serp, serpentine; tal, talc; trem, tremolite; zir, zircon

Table 6.1 (cont'd) Petrographic summary of rock types from the Stewarton Gabbro, Kings County, south-central New Brunswick

Ste #	Rock type	Main minerals (%)	Accessory minerals (%)	Alteration minerals	Texture and grain size (mm)	Vein and fracture filling
12/99	Anorthositic gabbro	pl (65-70), cpx (3-5), hbl (15-20), bio (7-10), Qtz (5-7), chl (2-5)	apa (5-7), ilm+mag (2-3), py+chp (<1)	seri, chl, bio, trem/act	tiny prismatic apa in hbl is ubiquitous; crude foliation, poikilitic; 0.5-1.0	
13/99	Pyroxene – olivine gabbro	pl (25-30), cpx (55-60), hbl (10-15), oli (7-10)	apa (1-2), ilm+mag (7-10), py+chp (<1)	chl, serp/tal, seri, act/trem	pl and cpx show reaction rim with myrmekitic-like intergrowth in contact with opaques; 0.5-3.0	
14/99	Pyroxene – hornblende gabbro	pl (25-30), cpx (55-60), hbl (10-15), oli (5-7)	apa (<1), ilm+mag (12-15), sph (<1), py+chp (<1)	chl, serp/tal, act/trem, seri, bowl, id	foliated; 0.5-3.0	
15/99	Pyroxene – hornblende gabbro	pl (25-30), cpx (45-50), hbl (15-20), bio (5-7)	apa (1-2), ilm+mag (5-7), py+chp (1-2), sph (1-2), carb (2-3)	epi group, preh, carb, seri, serp/tal	sheared, undulose extinction of bio, pl, cpx; cpx and pl are interfingered; 0.75-3.0	epi group, carb, sph in shear zones
16/99	Anorthositic gabbro	pl (50-55), cpx (45-50), hbl (10-15), oli (7-10)	apa (1-3), ilm+mag (4-7)	serp/tal, chl, act/trem, seri, bowl, id	poikilitic; ophitic to sub-ophitic; opaque minerals occur above cleavage of hbl; 1.0-3.0 mm prismatic crystals of apa ubiquitous; 2.0-4.0	epi group, preh in veins
19/99	Gabbroic anorthosite	pl (60-65), cpx (25-30), oli (10-15), hbl (10-12), bio (7-10)	apa (7-10), ilm+mag (10-12), py+chp (<1)	serp/tal, act/trem, seri, chl, bio, bowl, id	reaction rim at the interface of opaques, cpx and pl/oli; 0.5-1.0 and 1.0-3.0	
34	Gabbro-diabase contact rock with chilled margin	pl (60-65), cpx (1-2), amp (35-40)	ilm+mag+sph (1-2) aph (2-3), zir, Qtz (1-2)	act/trem/, seri, chl	poikilitic; (2-3)	
	chilled margin	pl (50-55), amp (45-50)	apa (1); sph (2-3)	seri, chl, hem	recrystallized; (0.03-0.05)	
	diabase	pl (50-55), cpx (10-15), amp (35-40)	ilm+mag (3-5), opa (2-3)		hypidiomorphic granular; (0.05-0.08)	
63	Porphyritic diabase	pl, phenos (10-12); groundmass: pl (40-45), amp (50-55)	ilm+mag (10-15), apa (1-2), sph (<1)	act/bio/chl, seri	recrystallized; matrix (0.1 to 0.2) pheno (2-5)	
101	Anorthosite intruded by granitoid vein	pl (60-65), Qtz (30-35) matrix (2-5)			myrmekitic texture, highly iniquigranular	
110	Felsite	pl (25-30), k-spar (35-40), Qtz (30-35), bio/chl (4-5)	rut (<1), epi (1-2)	goethite, limonite, seri	cataclastic and brecciated; (0.05-0.3)	
123	Granodiorite (Porphyry)	Phenos: pl (10-12), amp (10-12), Groundmass: pl (35-40) k-spar (20-25), amp/bio/chl (10-12)	apa (<1), zir,	chl, seri	Porphyritic; phenos (1.5-2.0) groundmass (0.05-0.1)	
210	Quartz diorite	pl (65-70), Qtz (15-20), bio/chl (3-5), k-spar (3-4)	sph (1-2)	seri, hem, carb		quartz and feldspar in shear zones
238A	Granodiorite	pl (35-40), Qtz (25-30), k-spar (25-30), chl/bio (7-10)		seri, musc, lim, goethite	cataclastic; porphyroclasts (0.5-0.8) matrix (0.05-0.2)	
238B	Granodiorite	pl (55-60), Qtz (10-15), k-spar (15-20), bio/chl (10-15)		seri, musc	cataclastic; (0.3-1.0)	
239	Granodiorite	pl (50-55), k-spar (10-12), Qtz (25-30), chl/bio (12-15)	zir (<1), opa (<1)	seri, chl, carb	cataclastic	

Abbreviation: apa, apatite; act, actinolite; bio, biotite; bowl, bowlingite; carb, carbonate; chl, chlorite; cpx, clinopyroxene; epi, epidote; hbl, hornblende; hem, hematite; id, iddingsite; ilm, ilmenite; kaer, kaersutite; mag, magnetite; oli, olivine; pl, plagioclase; preh, prehenite; py, pyrite; Qtz, quartz; rut, rutile; seri, sericite; serp, serpentine; tal, talc; trem, tremolite; zir, zircon

Table 6.1 (cont'd) Petrographic summary of rock types from the Stewarton Gabbro, Kings County, south-central New Brunswick

Ste #	Rock type	Main minerals (%)	Accessory minerals (%)	Alteration minerals	Texture and grain size (mm)	Vein and fracture filling
240	Quartz diorite - granodiorite	pl (45-50), qtz (35-40), bio/chl (7-10), k-spar (5-6)	apa (<1), epi (5-6)	seri, hem, epi	cataclastic; brecciated	
242	Quartz-phyric granite	qtz phenos (25-30); matrix: pl (35-40), k-spar (20-25) qtz (15-20) mica (5-6)		seri, musc, goethite, limonite, carb	cataclastic and brecciated; qtz phenos (3-5), matrix (0.05-0.1)	
234/90	Layered gabbro:				layered and foliated:	
	light layer	pl (75-80), cpx (1-2), hbl (10-12)	apa (1-2), ilm+mag (1-2)	chl, qtz, act/trem, seri/tal; 0.5-1.5, 2.0-5.0	layered and foliated; grain size grading	
	transition layer	pl (45-50), hbl (25-30), cpx (5-10)	apa (5-6), ilm+mag (5-7), qtz (3-5), carb (3-4), py+chp (<1)	hl, qtz, act/trem, serp/tal, seri; 0.5-1.5, 2.0-5.0	layered and foliated	
	dark layer	pl (5-10), cpx (15-20), hbl (50-60)	apa (1-2), ilm+mag (25-30), qtz (2-3), carb (2-3), py+chp (<1)	chl, qtz, act/trem, serp/tal seri; 0.5-1.5, 2.0-5.0	grain size grading and foliated	
Cum/Ste/1A	Cumberlandite	oli (35-40), pl (10-15), kaer (5-10)	ilm+mag (50-55), rut (1-2)	act/trem, serp/tal, kaer, seri, bowl, id	hypidiomorphic granular, pl is bent and deformed; (2-4)	

Abbreviation: apa, apatite; act, actinolite; bio, biotite; bowl, bowlingite; carb, carbonate; chl, chlorite; cpx, clinopyroxene; epi, epidote; hbl, hornblende; hem, hematite; id, iddingsite; ilm, ilmenite; kaer, kaersutite; mag, magnetite; oli, olivine; pl, plagioclase; preh, prehenite; py, pyrite; qtz, quartz; rut, rutile; seri, sericite; serp, serpentine; tal, talc; trem, tremolite; zir, zircon

Table 6.2. Petrography of selected drill core samples from the Lower Coverdale Gabbro, Albert County, southeastern New Brunswick.

Drill core sample #	Rock type	Main Minerals (%)	Accessory Minerals (%)	Alteration Minerals	Texture and grain size (mm)	Vein and fracture filling
KLOG/T2/1	Gabbroic anorthosite	carb matrix (40-45) carb (35-40), mica	apa (1-2), ilm+mag (2-3)	carb, bowl, id, chl, hem	Primary texture - totally lacking	carb, hem
KLOG/T2/2	Gabbroic anorthosite	pl (25-30), bio/chl (35-40), carb (15-20)	apa (5-7), ilm+mag (10-12) sph (1-2), qtz (1-2)	bowl, id, hem, seri, carb	Intensely sheared; primary texture destroyed; large (1-2 mm) apa fractured and sealed by carb	carb, qtz, chl
KLOG/T2/3	Pyroxene-olivine gabbro	pl (35-40), pseudo-cpx (25-30), pseudo-oli (20-25)	apa (12-15), ilm+mag (15-20), py (<1)	seri, bowl, id, hem, bio, chl, hem	No primary textures preserved	carb, nelsonite
KLOG/T2/4	Gabbroic anorthosite	pl (55-60), chl/bio/act/trem (35-40)	py+chp (1-2), ilm+mag (<1)	chl, bio, act, trem, carb, laum, seri	No primary textures preserved	carb, laum (extensive veining and patches up to 15-20%)
KLOG/T2/5	Anorthosite (pegmatitic)	pl (90-95), cpx (5-10)	ilm+mag (<1)	act/trem, chl/bio, carb, laum, seri, hem	Albite twins bent and deformed, (2-10)	carb, laum (veins and patches)
KLOG/T3/6	Sandstone	matrix (qtz+carb) (45-50), pebbles & frags (qtz, pl, k-spar, mica schist, slate, volcanic rocks, quartzite, phyllite)			Pebbles and fragments - subangular to subrounded	carb, qtz
KLOG/T3/7	Pyroxene-olivine gabbro	cpx (40-45), oli (10-15), pl (35-40), hbl (5-7)	apa (5-7), ilm+mag (7-8)			nelsonite, carb, hem, goth, tal
KLOG/T3/8	anorthosite	pl (90-95), cpx (5-10)	apa (<1)	carb, act/trem, bio/chl, tal/serp, id, bowl, seri, qtz, hem	cataclastic deformation, brecciation	laum, patches of laum, hem, carb
KLOG/T3/9	Gabbroic anorthosite	pl (40-45), oli (7-10), cpx (12-15), carb (30-35)	apa (5-7), ilm+mag (7-10)	act/trem, serp/talc, seri	primary texture not preserved apa (1-3 mm) (0.5-3.0)	
KLOG/T4/10	Pyroxene-olivine gabbro	cpx (35-40), oli (15-80), pla (35-40)	apa (7-10); ilm+mag (7-10), py+chp (<1)	act/trem, chl/bio, serp hem, bowl	carb, bio/chl, intense alteration	nelsonite, carb, hem
LC 94-1-1	Anorthosite (pegmatitic)	pl (85-90)	apa (2-3), ilm+mag (1-2), py+chp (<1)	hbl/bio/chl, qtz, trem/act	Fine-grained matrix of pl and qtz with megacrystic pl; apa (1-2 mm) prismatic and irregular	
LC 94-1-2	Gabbro	pl (40-45), qtz (5-10), act/trem/chl/bio (35-40)	ilm+mag (15-20), apa (2-3), sph (<1), py+chp (1-2)	act/trem/chl/bio	sheared and foliated	
LC 94-1-10	Diabase	pl (35-40), chl (55-60)	apa (5-6)		well foliated, some pl is zoned; (0.08 - 0.1)	carb
LC 94-1-11	Anorthosite	pl (70-75), k-spar (2-5), qtz (5-10)	apa (<1), ilm+mag (<1), zir	chl, bio, misc, seri	bent and deformed pl twins; intense shearing in rock	felsite, sph+opa
LC 94-1-12	Anorthosite	pl (85-90), chl/bio (7-10), qtz (5-6)	ilm+mag (5-6), sph (4-5)	mi, epi group	cataclastic deformation, silicification	mica
LC 94-1-13	Gabbro (ferro-gabbro)	pl (20-25), chl (40-45)	ilm+mag (40-45), sph (10-12), apa (2-3)	chl/trem/act, qu	intensely altered, sheared, brecciated and locally folded including opa	
LC 94-1-14	Quartz monzodiorite	pl (40-45), k-spar (12-15), qtz (15-20), chl (10-12)	ilm+mag (40-45), epi group (2-3), apa (1-2), carb (1-2)	epi, chl, seri	pl is deformed; matrix (<0.01), megacrysts pl (2.0 - 4.0)	
LC 95-1-15	Anorthosite	pl (95-98)	sph (<1), ilm+mag (<1), apa (<1)	seri, carb (extensive), laum (extensive)	cataclastic, breccia	carb, laum (extensive)
LC 95-1-16	Anorthosite	pl (90-95)	sph (<1), ilm+mag (<1), apa (<1)	seri, carb (extensive), laum (extensive)	breccia, cataclastic	carb, laum (extensive)

KLOG: Kilarney Oil and Gas Development Company Limited
LC: Noranda Mining and Exploration Inc.

Abbreviations: act, actinolite; apa, apatite; bio, biotite; bowl, bowlingite; carb, carbonate; chp, chalcopyrite; chl, chlorite; cpx, clinopyroxene; epi, epidote; hem, hematite; hbl, hornblende; id, iddingsite; k-spar, potash feldspar; laum, laumontite; mag, magnetite; musc, muscovite; oli, olivine; opa, opaque; pl, plagioclase; py, pyrite; qtz, quartz; seri, sericite; serp, serpentine; tal, talc; trem, tremolite

Table 6.2 (cont'd). Petrography of selected drill core samples from the Lower Coverdale Gabbro, Albert County, southeastern New Brunswick.

Drill core sample #	Rock type	Main minerals (%)	Accessory minerals (%)	Alteration minerals	Texture (mm)	Vein and fracture filling
LC 95-2-17	Gabbroic anorthosite	pl (60-65), act/trem/chl (15-20)	apa (15-20), ilm+mag (10-12)	seri, mica	sheared, inclusions of apa in pl; matrix (0.5 - 3.0); pl megacrysts (8.0-12.0)	mica and carb; nelsonite
LC 95-2-21	Quartz monzodiorite	qtz matrix (10-15), pl (35-40), k-spar (10-12), bio/chl/misc (15-20)	apa (<1)	seri, chl	subporphyritic; matrix (0.05-0.1), phenos (1.0-1.5)	
LC 95-3-3	Anorthosite	pl (85-90), tal/serp (5-10), chl/act/trem (10-15)		seri, chl,hem, laum,musc	inclusions of gabbro in anorthosite; sheared and cataclastic textures	laum, mica,carb
LC 95-3-8	Gabbro	pl (45-50), pseudo cpx (20-25), pseudo oli (15-20)	apa (12-15), ilm+mag (7-10)	act, trem, chl, serp, tal	foliated; (1.0-6.0) subrounded pl	serp+chl, nelsonite
LC 95-3-20	Anorthosite	pl (95-98)	sph (1-2), ilm+mag (1-2), chp (1-2)	seri, mica, carb,laum, qtz	intense fracturing, cataclastic breccia	carb+seri+qtz+mica

KLOG: Kilarney Oil and Gas Development Company Limited
LC: Noranda Mining and Exploration Inc.

Abbreviations: act, actinolite; apa, apatite; bio, biotite; bowl, bowlingite; carb, carbonate; chp, chalcopyrite; chl, chlorite; cpx, clinopyroxene; epi, epidote; hem, hematite; hbl, hornblende; id, iddingsite; k-spar, potash feldspar; laum, laumontite; mag, magnetite; musc, muscovite; oli, olivine; opa, opaque; pl, plagioclase; py, pyrite; qtz, quartz; seri, sericite; serp, serpentine; tal, talc; trem, tremolite

APPENDIX 7

Figure 7.1 The chemical classification and nomenclature of intrusive rocks of the Stewarton map area using a total alkalis versus silica diagram.

Table 7.1. Major element oxides in rocks from the Stewarton Gabbro, Kings County, south-central New Brunswick compared with selected reference rock suites.

Table 7.2. Trace and rare earth elements in rocks of the Stewarton Gabbro, Kings County, south-central New Brunswick.

Table 7.3a. Major element oxides in rocks from the Stewarton Gabbro, Kings County, south-central New Brunswick.

Table 7.3b. Major normative minerals in rocks from the Stewarton Gabbro, Kings County, south-central New Brunswick.

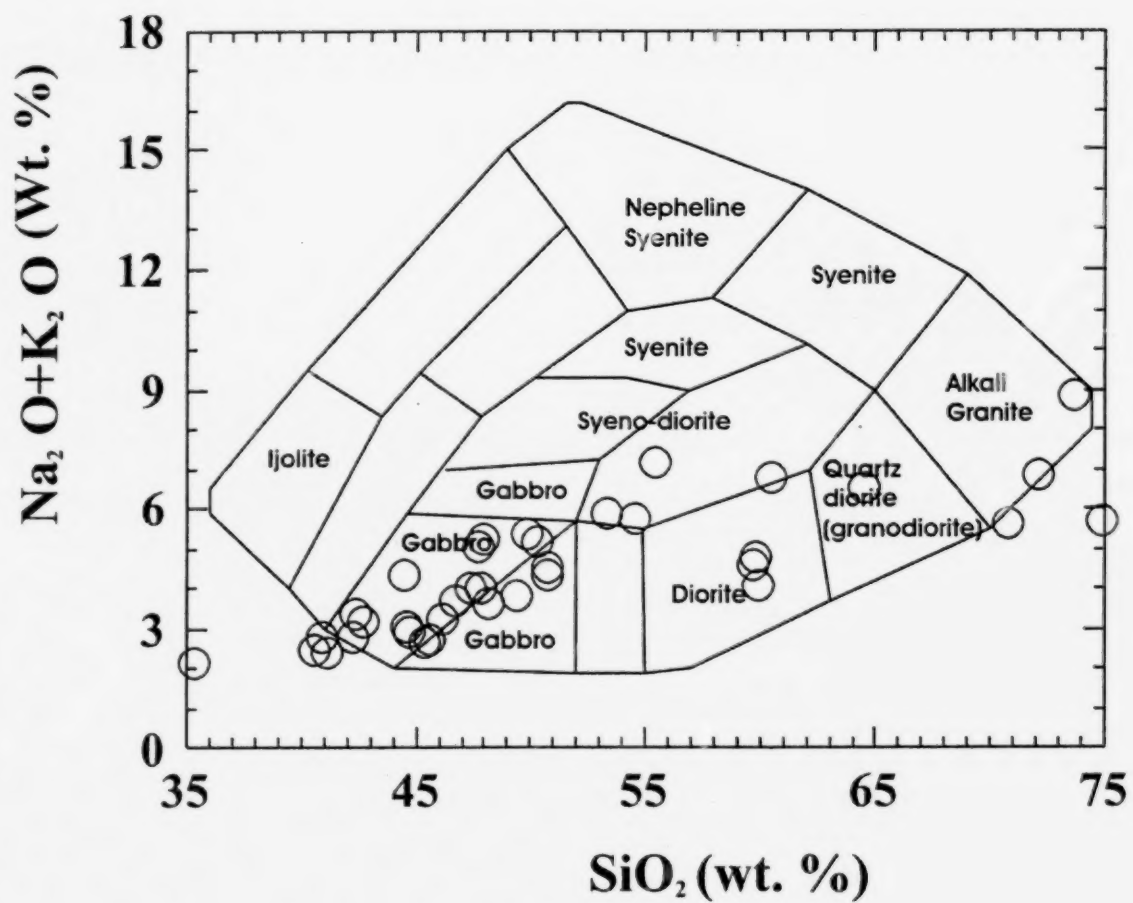


Figure 7.1 The chemical classification and nonmenclature of intrusive rocks of the Stewarton map area using a total alkalis versus silica diagram (after Cox et al. (1979).

Table 7.1. Major element oxides in rocks from the Stewarton Gabbro, Kings County, south-central New Brunswick compared with selected reference rock suites.

Sample	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O ₃ ⁷	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	LOI	TOTAL
STE/1A/99	55.39	1.28	17.27	7.64	0.17	1.26	6.72	6.81	0.29	0.21	1.66	98.71
STE/1B/99	42.33	6.02	10.75	20.72	0.44	5.61	8.06	2.55	0.81	1.76	1.38	100.43
STE/1C/99	40.92	4.72	11.00	24.86	0.51	5.84	6.87	1.96	0.84	1.16	1.43	100.12
STE/2/99	48.13	3.01	12.64	19.52	0.48	3.26	6.95	2.94	0.67	2.04	1.23	100.87
STE/3A/99	49.44	2.34	16.35	10.62	0.24	5.20	9.42	3.14	0.70	0.26	1.14	98.85
STE 3B/99	49.47	3.45	13.52	14.47	0.26	5.03	7.90	3.46	0.53	0.59	-0.01	98.67
STE/4/99	50.73	2.05	17.13	12.66	0.28	3.61	8.24	4.01	0.31	0.80	0.41	100.23
STE/05/99	47.76	3.31	19.46	9.00	0.14	3.73	10.87	3.14	0.33	0.15	0.79	98.68
STE/6A/99	45.60	3.64	13.09	14.68	0.24	7.50	11.69	2.37	0.22	0.14	0.83	100.01
STE/6B/99	44.72	3.18	13.96	16.09	0.23	7.10	10.49	2.69	0.24	0.21	0.78	98.69
STE/6C/99	59.95	1.83	16.01	6.57	0.11	2.68	6.03	3.83	0.60	0.16	1.21	98.98
STE/6D/99	46.18	2.82	15.16	13.54	0.19	6.29	10.40	2.64	1.01	0.15	1.08	99.45
STE/07/99	64.52	1.09	14.93	7.07	0.15	1.46	3.82	3.88	2.57	0.34	0.59	100.42
STE/08/99	47.98	2.82	15.04	10.48	0.19	6.35	10.36	2.69	0.94	0.10	1.92	98.87
STE/9/99	59.78	0.51	17.89	5.46	0.11	2.99	5.55	3.87	0.89	0.17	1.77	98.99
STE/10/99	47.88	3.72	14.26	12.08	0.21	5.95	10.23	3.11	0.34	0.12	0.68	98.58
STE/11/99	42.22	5.36	13.67	16.29	0.27	6.23	10.04	2.46	0.43	1.53	0.95	99.45
STE/12/99	54.57	1.13	16.33	11.77	0.28	1.40	5.74	5.32	0.50	0.46	1.44	98.94
STE/13/99	41.13	7.82	11.43	17.54	0.23	7.49	11.57	1.91	0.36	0.08	0.74	100.30
STE/14/99	42.69	5.33	13.59	16.95	0.23	6.25	8.99	2.82	0.59	0.16	1.38	98.98
STE/15/99	46.77	3.26	13.54	15.48	0.35	4.99	7.59	3.11	1.13	0.46	1.93	98.61
STE/16/99	47.70	2.44	16.92	11.98	0.24	4.26	8.64	3.93	0.57	1.05	1.32	99.05
STE/17/99	44.49	3.28	14.31	15.87	0.30	4.78	7.08	3.79	0.18	2.16	2.29	98.53
STE/18/99	45.38	2.53	16.98	12.03	0.24	5.58	11.62	2.50	0.15	0.22	1.58	98.81
STE/19/99	40.56	5.68	11.97	18.87	0.29	6.01	11.41	2.30	0.16	2.10	0.79	100.14
STE/20/99	35.36	5.94	10.78	19.11	0.32	7.01	12.09	1.95	0.37	5.17	2.30	100.40
STE/21/99	59.74	0.60	18.20	4.97	0.10	2.89	5.41	4.20	0.08	0.22	1.83	98.24
STE/22/99	44.61	1.50	16.96	11.32	0.20	7.70	4.56	2.98	1.04	0.15	7.63	98.65
STE/23/99	49.90	2.51	15.71	12.32	0.23	4.17	7.17	4.30	0.64	1.45	1.46	99.87
STE/24/99	50.32	2.56	14.77	11.86	0.26	4.05	8.12	4.54	0.42	0.97	0.68	98.56
STE/34A/01	53.28	1.64	16.93	8.72	0.18	3.08	7.98	5.48	0.69	0.30	0.00	98.28
STE/63/01	47.34	3.18	15.40	14.05	0.24	5.30	8.76	3.31	0.73	0.49	0.01	98.81
STE/123/01	70.79	0.38	13.79	4.93	0.11	0.20	1.42	4.89	3.26	0.06	0.00	99.83
STE/210/01	73.72	0.24	13.75	1.98	0.41	0.56	0.48	5.58	1.95	0.12	0.00	98.79
STE/217	60.45	0.23	21.55	2.30	0.04	0.62	4.38	6.77	1.33	0.10	1.94	99.70
STE/238A/01	75.06	0.15	13.98	1.56	0.16	0.42	0.69	4.56	2.72	0.08	0.00	99.38
STE/238B/01	72.12	0.33	14.69	3.07	0.33	1.07	0.89	4.11	1.86	0.11	0.00	98.58
STE/240/01	68.90	0.35	15.79	3.41	0.06	1.19	3.40	4.27	1.49	0.19	0.00	99.05
STE/242/01	77.07	0.14	12.08	1.63	0.03	0.08	0.67	4.97	2.06	0.04	0.00	98.77
STE/CUM	15.89	13.24	5.15	52.99	0.46	9.11	1.56	0.52	-0.01	0.23	-0.17	98.97
Olivine-free Gabbro ¹	48.15	2.64	18.02	13.07	0.12	5.25	10.17	3.46	0.14	0.05	0.22	101.29
Ferrodiorite ²	44.10	2.43	11.70	27.25	0.21	1.71	8.71	2.95	0.35	1.85	0.42	101.68
Melanogranophyre ³	60.23	1.18	11.29	15.64	0.24	0.51	5.11	3.92	1.94	0.27	0.90	101.23
Acid Granophyre ⁴	72.69	0.46	13.15	4.03	0.04	0.16	1.80	4.02	3.26	0.03	0.75	100.39
Gabbroic Anorthosite ⁴	48.55	1.09	23.13	10.19	0.00	1.84	13.43	2.21	0.15	-	-	100.59
Gabbro ⁴	48.36	1.32	16.84	11.35	0.18	8.06	11.07	2.26	0.56	0.24	0.64	100.88
Norite ⁷	50.28	0.89	17.67	9.59	0.14	9.27	9.72	1.96	0.63	0.21	0.47	100.83

Skaergaard Intrusion, middle zone; ² Skaergaard Intrusion, upper zone; ³ Skaergaard Intrusion; ⁴ Skaergaard Intrusion, transgressive sheet (Carmichael, I.S.E. et al. 1974); ⁵ Average from Doré Lake Complex, Québec (Allard, G.O. 1976); ⁶ Average of 160 analyses, (Nockolds, S.R. et al. 1978)⁷: Average of 39 analyses, (Nockolds, S.R. et al. 1978).

Table 7.2. Trace and rare-earth elements in rocks of the Stewarton Gabbro, Kings County, south-central New Brunswick.

Sample	Cu	Pb	Zn	Ni	Cr	V	Zr	Sr	Co	Be	Ba	Y	Hf	Sc	La	Nd	Sm	Eu	Yb
STE/1A/99	2	5	38	2	66	263	154	435	9	1	102	36	6.3	15	25.1	19.0	5.5	5.0	4.10
STE/1B/99	29	-	108	6	32	456	210	211	23	210	90	65	-	12	-	-	-	-	-
STE/1C/99	53	5	84	8	31	487	213	164	38	213	70	46	-	7	-	-	-	-	-
STE/2/99	35	5	126	4	75	71	226	266	22	2	157	81	6.3	80	32.5	38.0	13.7	4.7	8.10
STE/3A/99	64	2	57	37	144	325	136	291	23	136	110	37	-	3	-	-	-	-	-
STE/3B/99	102	2	70	21	81	429	245	260	28	245	63	53	-	7	-	-	-	-	-
STE/4/99	5	5	135	11	76	231	548	244	28	548	95	57	11.3	34	17.5	27.0	9.1	3.0	6.10
STE/05/99	12	2	27	6	59	376	98	373	14	98	58	21	-	4	-	-	-	-	-
STE/6A/99	83	2	60	63	135	582	86	262	39	86	39	27	-	5	-	-	-	-	-
STE/6B/99	31	5	100	41	166	587	67	272	50	67	45	25	2.0	53	6.0	11.0	3.7	1.6	2.50
STE/6C/99	17	2	47	23	106	211	139	238	16	139	95	20	-	4	-	-	-	-	-
STE/6D/99	49	2	55	27	65	620	58	317	34	58	128	17	-	6	-	-	-	-	-
STE/07/99	13	13	91	6	103	73	417	164	11	417	397	67	10.0	21	36.5	36.0	10.4	3.0	7.00
STE/08/99	85	3	54	31	142	572	78	315	24	78	122	21	-	5	-	-	-	-	-
STE/9/99	16	3	80	25	107	90	164	235	13	164	211	24	-	2	-	-	-	-	-
STE/10/99	26	5	72	7	92	443	76	289	40	78	72	19	2.7	53	5.0	9.0	3.5	1.5	2.30
STE/11/99	80	2	61	11	115	568	48	244	21	48	51	27	-	8	-	-	-	-	-
STE/12/99	23	3	91	3	43	22	69	280	3	69	114	60	-	9	-	-	-	-	-
STE/13/99	50	5	75	41	40	667	76	215	71	76	50	21	2.1	86	2.9	8.0	2.6	1.1	1.90
STE/14/99	40	2	54	9	59	673	53	276	37	53	109	18	-	13	-	-	-	-	-
STE/15/99	65	4	56	19	38	478	252	274	21	252	254	45	-	7	-	-	-	-	-
STE/16/99	16	5	101	14	76	180	98	437	29	98	102	42	2.6	30	14.1	24.0	7.7	3.2	3.60
STE/17/99	19	2	347	16	33	205	69	356	21	69	71	59	-	6	-	-	-	-	-
STE/18/99	68	5	115	18	146	435	17	306	43	17	46	15	0.5	49	3.0	4.0	2.4	1.3	1.70
STE/19/99	28	3	55	3	31	705	70	290	16	70	33	51	-	7	-	-	-	-	-
STE/20/99	47	2	86	6	19	647	41	309	40	41	32	74	-	6	-	-	-	-	-
STE/21/99	26	5	76	26	179	90	112	248	18	112	198	23	3.2	12	17.5	14.0	3.5	0.9	2.80
STE/22/99	114	2	117	89	218	294	55	194	43	55	100	8	-	16	-	-	-	-	-
STE/23/99	35	4	65	9	41	279	234	239	16	234	127	57	-	6	-	-	-	-	-
STE/24/99	27	5	139	8	64	263	202	200	28	202	113	178	7.8	36	78.0	112.0	29.7	6.1	18.00
STE/CUM	4	46	286	37	42	2698	22	67	119	-1	9	3	1.0	20	12	-5.0	0.8	0.4	0.40
STE/217	8	4	23	7	9	40	97	381	5	2	155	19	-	8	11.0	10.0	3.8	2.1	1.60

Table 7.3a. Major element oxides in rocks from the Stewarton Gabbro, Kings County, south-central New Brunswick.

Sample	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O ₃ ^T	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	LOI	TOTAL
STE/1A/99	55.39	1.28	17.27	7.64	0.17	1.26	6.72	6.81	0.29	0.21	1.66	98.71
STE/1B/99	42.33	6.02	10.75	20.72	0.44	5.61	8.06	2.55	0.81	1.76	1.38	100.43
STE/1C/99	40.92	4.72	11.00	24.86	0.51	5.84	6.87	1.96	0.84	1.16	1.43	100.12
STE/2/99	48.13	3.01	12.64	19.52	0.48	3.26	6.95	2.94	0.67	2.04	1.23	100.87
STE/3A/99	49.44	2.34	16.35	10.62	0.24	5.20	9.42	3.14	0.70	0.26	1.14	98.85
STE 3B/99	49.47	3.45	13.52	14.47	0.26	5.03	7.90	3.46	0.53	0.59	-0.01	98.67
STE/4/99	50.73	2.05	17.13	12.66	0.28	3.61	8.24	4.01	0.31	0.80	0.41	100.23
STE/05/99	47.76	3.31	19.46	9.00	0.14	3.73	10.87	3.14	0.33	0.15	0.79	98.68
STE/6A/99	45.60	3.64	13.09	14.68	0.24	7.50	11.69	2.37	0.22	0.14	0.83	100.01
STE/6B/99	44.72	3.18	13.96	15.09	0.23	7.10	10.49	2.69	0.24	0.21	0.78	98.69
STE/6C/99	59.95	1.83	16.01	6.57	0.11	2.68	6.03	3.83	0.60	0.16	1.21	98.98
STE/6D/99	46.18	2.82	15.16	13.54	0.19	6.29	10.40	2.64	1.01	0.15	1.08	99.45
STE/07/99	64.52	1.09	14.93	7.07	0.15	1.46	3.82	3.88	2.57	0.34	0.59	100.42
STE/08/99	47.98	2.82	15.04	10.48	0.19	6.35	10.36	2.69	0.94	0.10	1.92	98.87
STE/9/99	59.78	0.51	17.89	5.46	0.11	2.99	5.55	3.87	0.89	0.17	1.77	98.99
STE/10/99	47.88	3.72	14.26	12.08	0.21	5.95	10.23	3.11	0.34	0.12	0.68	98.58
STE/11/99	42.22	5.36	13.67	16.29	0.27	6.23	10.04	2.46	0.43	1.53	0.95	99.45
STE/12/99	54.57	1.13	16.33	11.77	0.28	1.40	5.74	5.32	0.50	0.46	1.44	98.94
STE/13/99	41.13	7.82	11.43	17.54	0.23	7.49	11.57	1.91	0.36	0.08	0.74	100.30
STE/14/99	42.69	5.33	13.59	16.95	0.23	6.25	8.99	2.82	0.59	0.16	1.38	98.98
STE/15/99	46.77	3.26	13.54	15.48	0.35	4.99	7.59	3.11	1.13	0.46	1.93	98.61
STE/16/99	47.70	2.44	16.92	11.98	0.24	4.26	8.64	3.93	0.57	1.05	1.32	99.05
STE/17/99	44.49	3.28	14.31	15.87	0.30	4.78	7.08	3.79	0.18	2.16	2.29	98.53
STE/18/99	45.38	2.53	16.98	12.03	0.24	5.58	11.62	2.50	0.15	0.22	1.58	98.81
STE/19/99	40.56	5.68	11.97	18.87	0.29	6.01	11.41	2.30	0.16	2.10	0.79	100.14
STE/20/99	35.36	5.94	10.78	19.11	0.32	7.01	12.09	1.95	0.37	5.17	2.30	100.40
STE/21/99	59.74	0.60	18.20	4.97	0.10	2.89	5.41	4.20	0.08	0.22	1.83	98.24
STE/22/99	44.61	1.50	16.96	11.32	0.20	7.70	4.56	2.98	1.04	0.15	7.63	98.65
STE/23/99	49.90	2.51	15.71	12.32	0.23	4.17	7.17	4.30	0.64	1.46	1.46	99.87
STE/24/99	50.32	2.56	14.77	11.86	0.26	4.05	8.12	4.54	0.42	0.97	0.01	97.89
STE/34A/01	53.28	1.64	16.93	8.72	0.18	3.08	7.98	5.48	0.69	0.30	0.00	98.28
STE/63/01	47.34	3.18	15.40	14.05	0.24	5.30	8.76	3.31	0.73	0.49	0.01	98.81
STE/123/01	70.79	0.38	13.79	4.93	0.11	0.20	1.42	4.89	3.26	0.06	0.00	99.83
STE/210/01	73.72	0.24	13.75	1.98	0.41	0.56	0.48	5.58	1.95	0.12	0.00	98.79
STE/217	60.45	0.23	21.55	2.30	0.04	0.62	4.38	6.77	1.33	0.10	0.00	97.77
STE/238A/01	75.06	0.15	13.98	1.56	0.16	0.42	0.69	4.56	2.72	0.08	0.00	99.38
STE/238B/01	72.12	0.33	14.69	3.07	0.33	1.07	0.89	4.11	1.86	0.11	0.00	98.58
STE/240/01	68.90	0.35	15.79	3.41	0.06	1.19	3.40	4.27	1.49	0.19	0.00	99.05
STE/242/01	77.07	0.14	12.08	1.63	0.03	0.08	0.67	4.97	2.06	0.04	0.00	98.77
STE/CUM	15.89	13.24	5.15	52.99	0.46	9.11	1.56	0.52	-0.01	0.23	-0.17	98.97
Olivine-free Gabbro ¹	48.15	2.64	18.02	13.07	0.12	5.25	10.17	3.46	0.14	0.05	0.22	101.29
Ferrodiorite ²	44.10	2.43	11.70	27.25	0.21	1.71	8.71	2.95	0.35	1.85	0.42	101.68
Melanogranophyre ³	60.23	1.18	11.29	15.64	0.24	0.51	5.11	3.92	1.94	0.27	0.90	101.23
Acid Granophyre ⁴	72.69	0.46	13.15	4.03	0.04	0.16	1.80	4.02	3.26	0.03	0.75	100.39
Gabbroic Anorthosite ⁵	48.55	1.09	23.13	10.19	0.00	1.84	13.43	2.21	0.15	-	-	100.59
Gabbro ⁶	48.36	1.32	16.84	11.35	0.18	8.06	11.07	2.26	0.56	0.24	0.64	100.88
Norite ⁷	50.28	0.89	17.67	9.59	0.14	9.27	9.72	1.96	0.63	0.21	0.47	100.83

¹Skaergaard Intrusion, middle zone; ²Skaergaard Intrusion, upper zone; ³Skaergaard Intrusion; ⁴Skaergaard Intrusion, transgressive sheet (Carmichael, I.S.E. et al. 1974); ⁵Average from Doré Lake Complex, Québec (Allard, G.O. 1976); ⁶Average of 160 analyses, (Nockolds, S.R. et al. 1978) ⁷Average of 39 analyses, (Nockolds, S.R. et al. 1978).

Table 7.3b. Major normative minerals in rocks from the Stewarton Gabbro, Kings County, south-central New Brunswick.

Sample	Q	C	Z	Or	Ab	An	D1	Wo	Hy	Oi	Mt	Cm	Hm	Il	Tn	Ru	Ap	TOTAL
STE/1A/99	2.45	0.00	0.03	1.71	57.62	15.72	6.78	1.64	0.00	0.00	0.00	0.01	7.64	0.36	2.68	0.00	0.50	97.14
STE/1B/99	6.50	0.00	0.04	4.79	21.58	15.50	0.00	0.00	13.97	0.00	0.00	0.01	20.72	0.94	9.22	1.76	4.17	98.20
STE/1C/99	7.80	0.00	0.04	4.96	16.58	18.75	0.00	0.00	14.54	0.00	0.00	0.01	24.86	1.10	5.52	1.90	2.75	99.81
STE/2/99	14.82	0.00	0.05	3.96	24.87	19.33	0.00	0.00	8.12	0.00	0.00	0.02	19.52	1.02	1.38	1.90	4.84	99.83
STE/3A/99	4.84	0.00	0.03	4.14	26.57	28.47	7.38	0.00	9.53	0.00	0.00	0.03	10.62	0.50	5.09	0.00	0.62	97.82
STE 3B/99	7.87	0.00	0.05	3.13	29.81	19.81	3.62	0.00	10.85	0.00	0.00	0.02	14.47	0.56	7.75	0.00	1.40	98.80
STE/4/99	7.07	0.00	0.11	1.83	33.93	27.85	1.45	0.00	8.32	0.00	0.00	0.02	12.66	0.59	4.27	0.00	1.90	100.00
STE/05/99	2.99	0.00	0.02	1.95	26.57	38.05	3.15	0.00	7.83	0.00	0.00	0.01	9.00	0.29	7.75	0.00	0.36	97.97
STE/6A/99	2.16	0.00	0.02	1.30	20.05	24.44	16.36	0.00	11.09	0.00	0.00	0.03	14.68	0.52	8.27	0.00	0.33	99.25
STE/6B/99	1.14	0.00	0.01	1.42	22.76	25.32	11.90	0.00	12.17	0.00	0.00	0.04	15.09	0.49	7.18	0.00	0.50	98.02
STE/6C/99	19.78	0.00	0.03	3.55	32.41	24.74	0.00	0.00	6.67	0.00	0.00	0.02	6.57	0.23	2.99	0.49	0.38	97.86
STE/6D/99	0.89	0.00	0.01	5.97	22.34	26.55	11.79	0.00	10.20	0.00	0.00	0.01	13.54	0.40	6.40	0.00	0.36	98.46
STE/07/99	33.49	0.00	0.01	15.45	39.34	4.50	4.22	0.00	0.10	0.00	0.00	0.00	0.93	0.02	0.24	0.00	0.07	98.37
STE/08/99	22.87	0.00	0.08	15.19	32.83	15.77	0.00	0.00	3.64	0.00	0.00	0.02	7.07	0.32	0.80	0.60	0.81	100.00
STE/09/99	2.62	0.00	0.02	5.56	22.76	26.21	12.16	0.00	10.18	0.00	0.00	0.03	10.48	0.40	6.40	0.00	0.24	97.06
STE/10/99	17.93	0.84	0.03	5.26	32.74	26.57	0.00	0.00	7.45	0.00	0.00	0.02	5.46	0.23	0.00	0.39	0.40	97.32
STE/11/99	3.63	0.00	0.02	2.01	26.31	23.96	10.90	0.00	9.77	0.00	0.00	0.02	12.08	0.45	8.56	0.00	0.28	97.99
STE/12/99	2.96	0.00	0.01	2.54	20.81	25.00	0.00	0.00	15.52	0.00	0.00	0.02	16.29	0.56	10.51	0.79	3.63	98.64
STE/13/99	0.52	0.00	0.02	2.13	16.16	21.56	7.11	0.00	15.36	0.00	0.00	0.01	17.54	0.52	18.52	0.00	0.19	99.64
STE/14/99	0.38	0.00	0.01	3.49	23.86	22.70	2.60	0.00	14.36	0.00	0.00	0.01	16.95	0.49	12.44	0.00	0.38	97.67
STE/15/99	5.14	0.00	0.05	6.68	26.31	19.67	4.01	0.00	10.57	0.00	0.00	0.01	15.48	0.75	7.05	0.00	1.09	96.81
STE/16/99	2.69	0.00	0.02	3.37	33.25	26.87	1.37	0.00	9.98	0.00	0.00	0.02	11.98	0.51	5.33	0.00	2.49	97.88
STE/17/99	5.50	0.13	0.01	1.06	32.07	21.16	0.00	0.00	11.90	0.00	0.00	0.01	15.87	0.65	0.00	2.94	5.13	96.43
STE/18/99	2.29	0.00	0.00	0.89	21.15	34.68	10.71	0.00	8.94	0.00	0.00	0.03	12.03	0.50	5.57	0.00	0.52	97.31
STE/19/99	3.60	0.00	0.01	0.95	19.46	21.88	1.95	0.00	14.07	0.00	0.00	0.01	18.87	0.62	13.13	0.00	4.98	99.53
STE/20/99	2.24	0.00	0.01	2.19	16.50	19.58	0.00	0.00	17.46	0.00	0.00	0.00	19.11	0.68	4.75	3.65	12.26	98.43
STE/21/99	19.68	1.86	0.02	0.46	35.54	25.55	0.00	0.00	7.20	0.00	0.00	0.04	4.97	0.21	0.00	0.49	0.52	96.54
STE/22/99	2.43	2.97	0.01	6.15	25.21	21.74	0.00	0.00	19.18	0.00	0.00	0.05	11.32	0.42	0.00	1.28	0.36	91.12
STE/23/99	5.88	0.00	0.05	3.78	36.38	21.69	0.00	0.00	10.39	0.00	0.00	0.01	12.32	0.49	3.14	0.97	3.46	98.56
STE/24/99	4.87	0.00	0.04	2.48	38.41	18.70	5.80	0.00	7.40	0.00	0.00	0.01	11.86	0.56	5.57	0.00	2.30	98.00
STE/34A/01	1.79	0.00	0.01	4.08	46.37	19.58	10.31	0.00	2.90	0.00	0.00	0.00	8.72	0.40	3.51	0.00	0.71	98.38
STE/63/01	3.25	0.00	0.05	4.31	28.01	25.02	4.10	0.00	11.30	0.00	0.00	0.02	14.05	0.53	7.12	0.00	1.16	98.92
STE/123/01	26.76	0.00	0.13	19.28	41.37	6.07	0.00	0.00	0.50	0.00	0.00	0.00	4.93	0.24	0.50	0.05	0.14	99.97
STE/210/01	32.22	1.85	0.02	11.56	47.21	1.67	0.00	0.00	1.39	0.00	0.65	0.00	1.53	0.45	0.00	0.00	0.29	98.84
STE/217	5.88	1.20	0.02	7.86	57.28	21.26	0.00	0.00	1.54	0.00	0.00	0.00	2.30	0.08	0.00	0.19	0.24	97.85
STE/238A/01	36.20	2.45	0.02	16.10	38.58	2.98	0.00	0.00	1.05	0.00	0.09	0.00	1.50	0.28	0.00	0.00	0.19	99.44
STE/238B/01	37.85	4.53	0.03	11.02	34.77	3.79	0.00	0.00	2.66	0.00	0.13	0.00	2.98	0.62	0.00	0.00	0.26	98.64

¹Skaergaard Intrusion, middle zone; ²Skaergaard Intrusion, upper zone; ³Skaergaard Intrusion; ⁴Skaergaard Intrusion, transgressive sheet (Carmichael, I.S.E. et al. 1974); ⁵Average from Doré Lake Complex, Québec (Allard, G.O. 1976); ⁶Average of 160 analyses; (Nockolds, S.R. et al. 1978); ⁷Average of 39 analyses (Nockolds, S.R. et al. 1978).

Q, quartz; C, corundum; Z, zircon; Or, orthoclase; Ab, albite; An, anorthosite; Di, diopside; Wo, wollastonite; Hy, hypersthene; Ol, olivine; Mt, magnetite; Cm, chromite; Hm, hematite; Il, ilmenite; Tn, sphene; Ru, rutile; Ap, apatite.

Table 7.3b (cont'd). Normative minerals in rocks from the Stewarton Gabbro, Kings County, south-central New Brunswick.

Sample	Q	C	Z	Or	Ab	An	D1	Wo	Hy	Ol	Mt	Cm	Hm	Il	Tn	Ru	Ap	TOTAL
STE/240/01	29.75	1.37	0.03	8.83	36.13	15.81	0.00	0.00	2.96	0.00	0.00	0.00	3.41	0.13	0.00	0.28	0.45	99.15
STE/242/01	38.79	0.53	0.04	12.20	42.05	3.12	0.00	0.00	0.20	0.00	0.00	0.00	1.63	0.07	0.00	0.11	0.10	98.84
STE/CUM	0.00	2.00	0.00	0.02	4.40	6.26	0.00	0.00	11.23	8.03	0.00	0.01	52.99	1.01	0.00	12.71	0.55	99.21
Olivine-free Gabbro ¹	0.00	0.00	0.00	0.83	29.27	33.23	13.91	0.00	4.47	9.52	3.65	0.00	0.00	5.01	0.00	0.00	0.12	100.01
Ferrodiorite ²	0.00	0.00	0.00	2.07	24.96	17.65	11.81	0.00	17.27	13.10	2.97	0.00	0.00	4.61	0.00	0.00	4.38	98.82
Melanogranophyre ³	17.67	0.00	0.00	11.47	33.17	7.48	14.11	0.00	4.55	0.00	8.00	0.00	0.00	2.24	0.00	0.00	0.64	99.33
Acid Granophyre ⁴	31.25	0.00	0.00	19.27	34.01	8.21	0.46	0.00	3.85	0.00	1.33	0.00	0.00	0.87	0.00	0.00	0.07	99.32
Gabbroic Anorthosite ⁵																		0.00
Gabbro ⁶	0.00	0.00	0.00	3.31	19.12	34.16	15.57	0.00	13.40	7.05	3.70	0.00	0.00	2.51	0.00	0.00	0.57	99.39
Norite ⁷	0.00	0.00	0.00	3.72	16.58	37.56	7.52	0.00	28.03	2.05	1.88	0.00	0.00	1.69	0.00	0.00	0.50	99.53

¹Skaergaard Intrusion, middle zone; ²Skaergaard Intrusion, upper zone; ³Skaergaard Intrusion, transgressive sheet (Carmichael, I.S.E. et al. 1974); ⁴Average from Doré Lake Complex, Québec (Allard, G.O. 1976); ⁵Average of 160 analyses; (Nockolds, S.R. et al. 1978); ⁶Average of 39 analyses (Nockolds, S.R. et al. 1978).

Q, quartz; C, corundum; Z, zircon; Or, orthoclase; Ab, albite; An, anorthosite; Di, diopside; Wo, wollastonite; Hy, hypersthene; Ol, olivine; Mt, magnetite; Cm, chromite; Hm, hematite; ilmenite; Tn, sphene; Ru, rutile; Ap, apatite.

APPENDIX 8

Report 1: Interpretation of geophysical data mapped over the Lower Coverdale and Stewarton gabbro bodies in New Brunswick.

REPORT 1:
INTERPRETATION OF GEOPHYSICAL DATA
MAPPED OVER THE LOWER COVERDALE
AND STEWARTON GABBRO BODIES
IN NEW BRUNSWICK.

by
Kenneth B.S. Burke

August 30, 2000

Introduction.

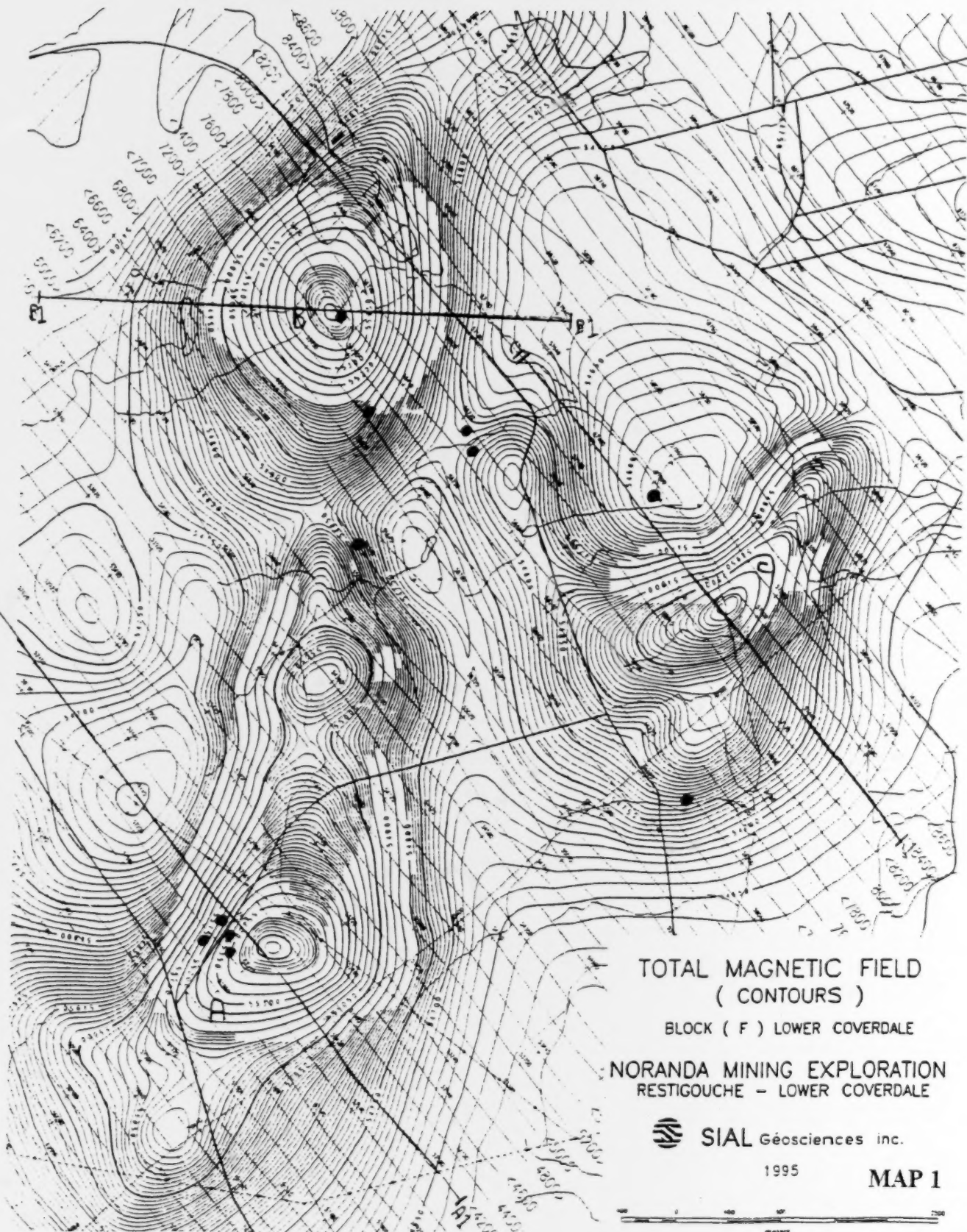
An interpretation has been made of available geophysical data mapped over the Lower Coverdale and Stewarton gabbro bodies in New Brunswick. The data in the Lower Coverdale area consists of an aeromagnetic survey flown by Sial Geoscience Inc. for Noranda Mining Exploration in 1995, gravity data from a compilation of New Brunswick gravity data by Hassan (2000) and one seismic reflection section acquired by Chevron in 1991. In the Stewarton area, the data available are an aeromagnetic survey flown by the GSC in 1987 and again New Brunswick gravity data compiled by Hassan (2000). Three anomalies identified in a GSC aeromagnetic map flown in the Lower Coverdale area in 1958 had previously been interpreted semi-quantitatively in an Open File report released in 1989 (Burke, 1989), but the new aeromagnetic data from Sial Geoscience Inc. was flown at a lower altitude (90m nominal ground clearance) and closer line spacing (200 m) and offered better resolution of the anomalies. Similarly, a profile from an airbourne fluxgate magnetometer survey flown by the GSC in 1956 had been interpreted by Burke (1995), but data from a more recently flown cesium vapor magnetometer survey in 1987 by the GSC offered superior detail and resolution of anomalies. The flight parameters for this latter survey were a nominal ground clearance of 150 m and average flight line spacing of 300 m, with both vertical gradient and total field contour maps being produced.

Lower Coverdale gabbro bodies.

Profiles of total magnetic field values were taken across the three anomalies on the Sial Geoscience Inc. aeromagnetic map (A1, B1 and C1; Map1) and these values and distances entered into a 2 3/4 magnetic/gravity modelling program MAGIXP™. Magnetic susceptibility measurements were made on a collection of borehole samples and the mean value of 0.053592 S.I. units (Table 1) was adopted as the representative value for the gabbro bodies. However, note the wide variation of individual measurements, as indicated by the standard deviation of 0.051102 S.I. units being almost the same as the mean value. Each profile was then modelled by starting with a rectangular prism with vertical sides under the position of the half maximum amplitude value and then adding in more vertices until an approximate fit of calculated response to the observed values was obtained. Finally, the automatic inversion procedure using iterative methods was used to obtain body parameters for an optimum fit.

Profile A1.

This profile was taken along a northwest - southeast flight line closest to the maximum value of anomaly A (Map 1). The profile was positioned 1 km from the southwestern end of the gabbro



TOTAL MAGNETIC FIELD
(CONTOURS)

BLOCK (F) LOWER COVERDALE

NORANDA MINING EXPLORATION
RESTIGOUCHE - LOWER COVERDALE

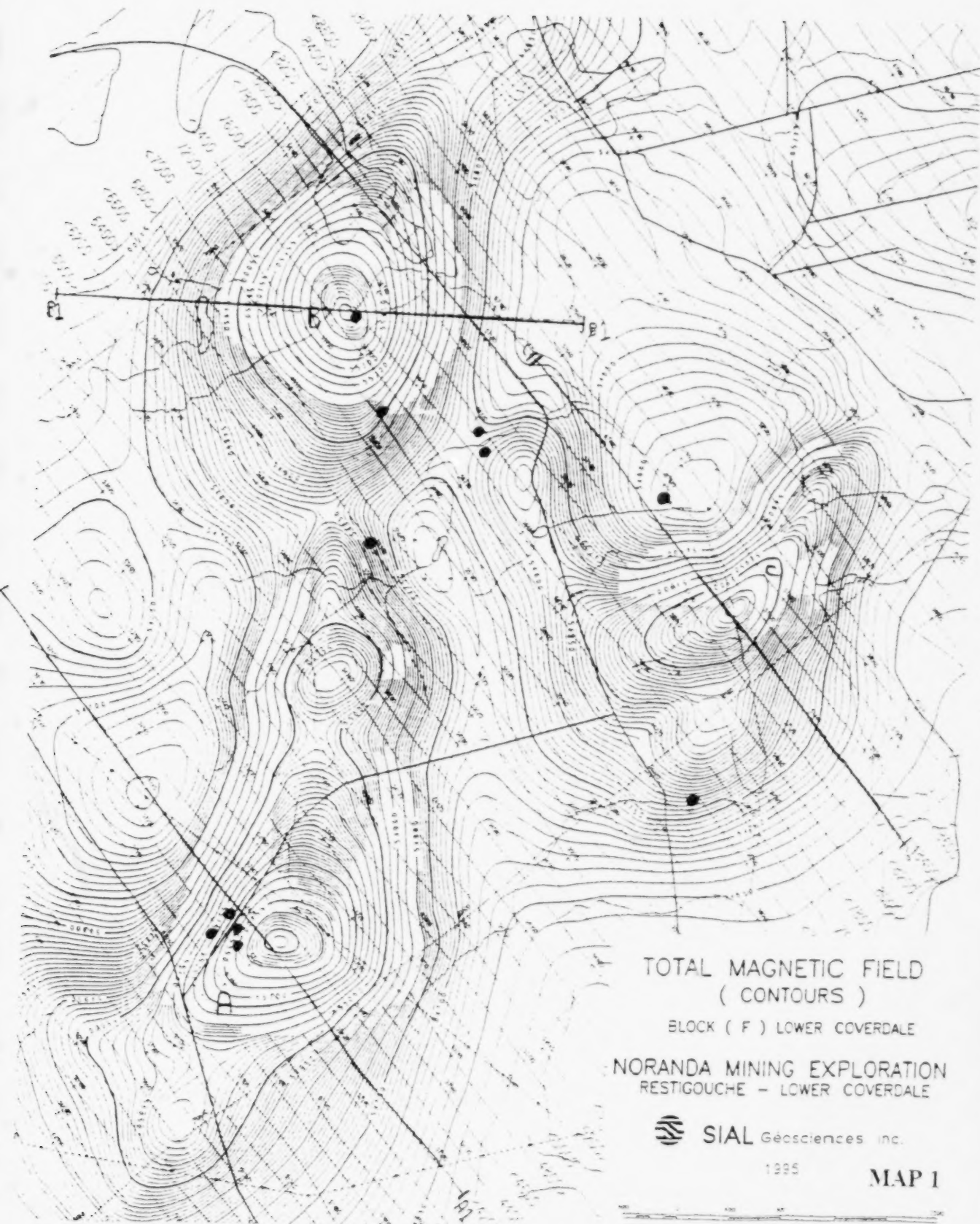


SIAL Géosciences inc.

1995

MAP 1





TOTAL MAGNETIC FIELD
(CONTOURS)

BLOCK (F) LOWER COVERDALE

NORANDA MINING EXPLORATION
RESTIGOUCHE - LOWER COVERDALE



SIAL Géosciences inc.

1985

MAP 1

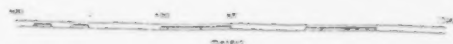


Table 1

**MAGNETIC SUSCEPTIBILITY MEASUREMENTS FOR
LOWER COVERDALE AND STEWARTON GABBROS**

Stewarton		Lower Coverdale	
	k S.I. units		k S.I. units
Sample from pit with pyroxene clots	0.0495	LC94-1-1	0.042
	0.0301	LC94-1-2	0.0175
Sample near cumberlandite		LC94-1-3	0.172
	0.0547	LC94-1-4	0.0842
	0.1041		
	0.0953	LC95-3-5	0.00011
Layered sample	0.131	LC95-3-6	0.0432
		LC95-3-7	0.027
	0.0679	LC95-3-8	0.0685
	0.08	LC95-3-20	0.0037
	0.0824		
	0.0724	LC95-2-17	0.0821
Mean		LC95-2-19	0.102
	0.07674	LC95-2-21	0.00079
Standard deviation	0.029021	Mean	0.053592
Cumberlandite		Standard deviation	0.051102
	0.5		
	0.598		
Mean	0.654		
	0.584		

body and 8 km from the northeastern end. The geomagnetic elements for 1995 of total field value of 54714 nT, a dip of 70.6° and a declination of 20.7° were used as the parameters of the inducing field and no remanent magnetisation was assumed. The final model fit is shown in Plate LCA2 and the coordinates of the vertices of the body listed in Appendix 1. The gabbro body has a latholithic shape with a thickness of 1000 m buried 150 m below the surface.

Profile B1.

This profile was taken along a west - east line through the maximum value of anomaly B (Map 1). The profile was positioned over the centre of the gabbro body, about 1.5 km from the ends. The same geomagnetic elements for 1995 as above were used as the parameters of the inducing field and no remanent magnetisation was assumed. The final model fit is shown in Plate LCB2 and the coordinates of the vertices of the body listed in Appendix 1. The gabbro body again has a latholithic shape with a thickness of 1100 m buried 164 m below the surface.

Profile C1.

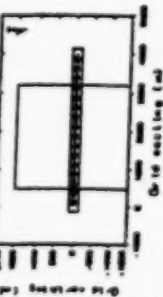
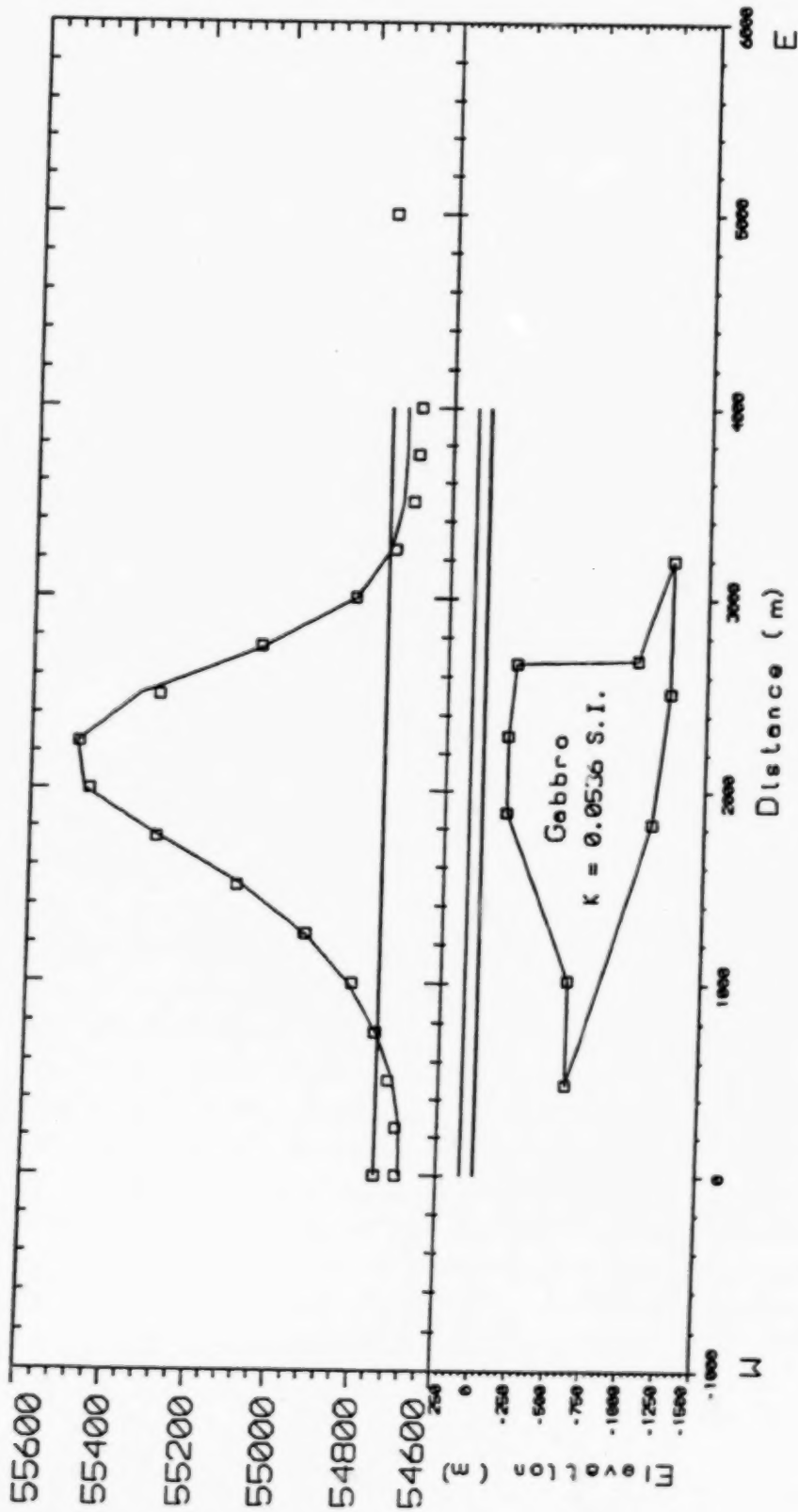
This profile was taken along a northwest - southeast flight line through the maximum value of anomaly C. (Map 1). The profile was positioned over the centre of the gabbro body, about 1.5 km from the ends. The same geomagnetic elements as above were used as the parameters of the inducing field and no remanent magnetisation was assumed. The final model fit is shown in Plate LCC2 and the coordinates of the vertices of the body listed in Appendix 1. The gabbro body again has a latholithic shape with a maximum thickness of 800 m, but thinning rapidly to the southeast. The gabbro is buried from 134m to 155 m below the surface.

Gravity data.

Gravity values and coordinates for the Lower Coverdale area taken from Hassan (2000) were entered into the program Surfer™ and plotted in contour map form (see Appendix 2). An inspection of the contours and a comparison of the position of the gravity highs with the map of the aeromagnetic anomalies showed a horizontal displacement of the gravity anomalies compared to the magnetic anomalies. It was concluded that aliasing of the gravity anomalies had taken place because of the sparseness of stations and no quantitative interpretation of the gravity anomalies was made.

Seismic reflection section.

Seismic reflection line 63Y was shot along the north - south highway lying, along the western flank of magnetic anomaly C. Shot point numbers decrease from north to south and shot point 3603



Inducing field : 54714, nT		DNRE		Plate: LCB2	
Lat: 78.68 deg	Dist: -28.78 deg	University of New Brunswick		Gabbro body	
Surto Direction : 188.00 deg		Date: 18-AUG-88		Lower Cavendish Fracture 211/2	
Profile Direction : 98.00 deg		Date: 18-AUG-88		Albert, N.B.	
At Direction are Calculated from true north		Profile: B-B'		Profile Scale: 1:2000 Vert. Excep: 6.78:1	

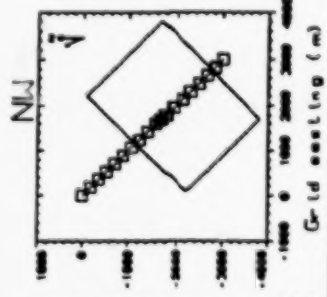
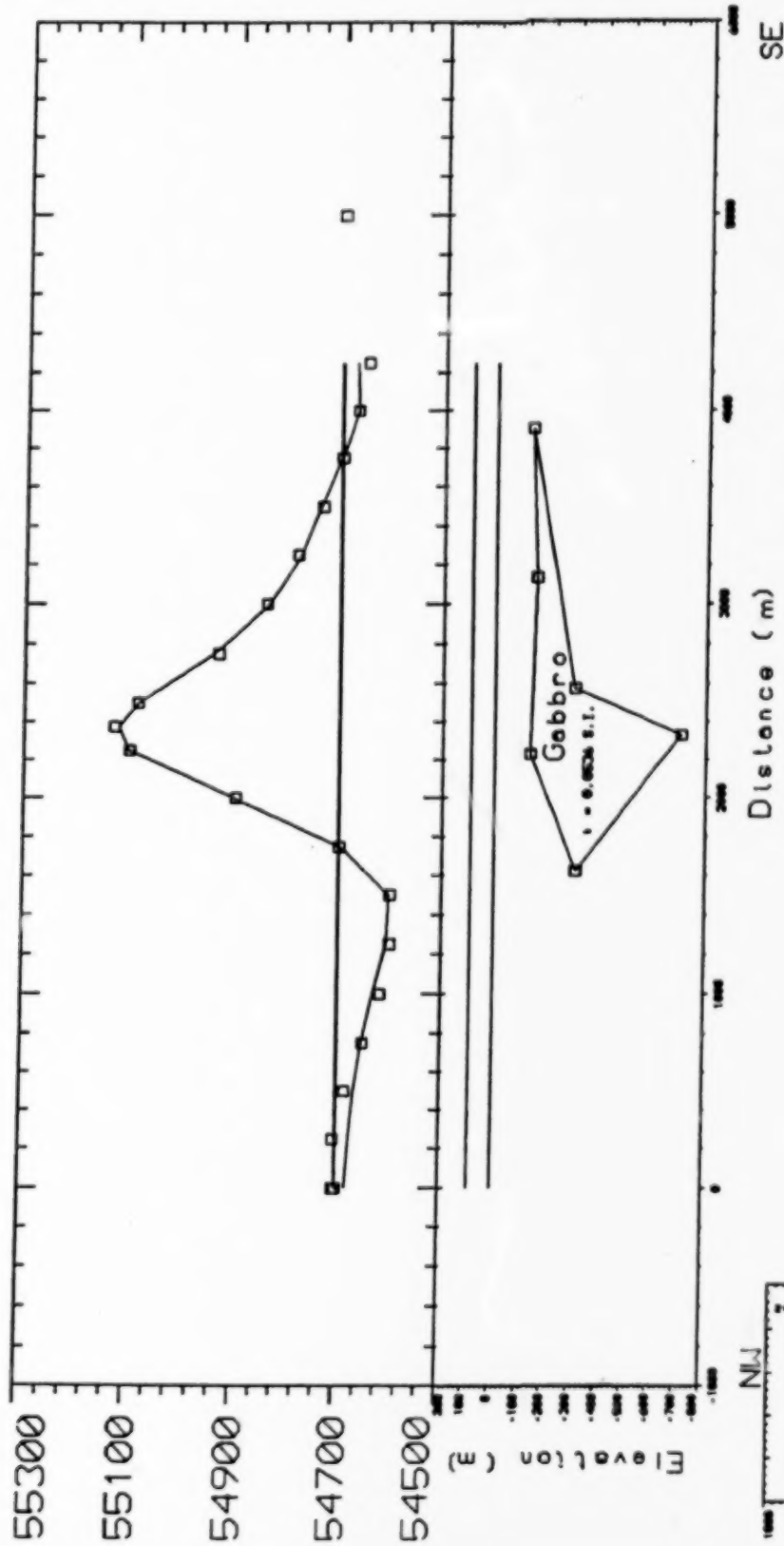


Plate: LCC2

Inducing field: 54714, nT		DNRE		Gabbro body	
East: 70.60 deg	Decl: -20.70 deg	University of New Brunswick		Lower Coverdale Mosaic 211/2	
Strike Direction: 45.00 deg		Date Set: LCC2C102		Albert, N.B.	
Profile Direction: 120.00 deg		Date Set: 18-AUG-80		Profile: C-C'	
All Directions are Gradients from true north		New Station 1811423		Profile Station 182009 North, Group 1, 2711	

is approximately 200 m, north of the junction with the NNE trending road from the west. A portion of the seismic reflection profile is shown in Appendix 3. The decrease of reflection events from 400 and 500 milliseconds between shot points 3676 and 3603 is probably caused by the presence of intrusive rocks, possibly representing the deeper flanks of the gabbro body.

Stewarton gabbro body.

Profiles of total magnetic field values were taken across the anomaly on the 1:20000 GSC aeromagnetic map (A1 and B1; Map2) and these values and distances entered into the 2 3/4 magnetic/gravity modelling program MAGIXP™. Magnetic susceptibility measurements were made on a collection of outcrop samples and the mean value of 0.07674 S.I. units (Table 1) was adopted as the representative value for the gabbro body. However, again note the wide variation of individual measurements as indicated by the standard deviation of 0.029021 S.I. units.

Profile B1.

This profile was taken along a northwest - southeast flight line through the maximum value of anomaly (Map 2). The profile was positioned approximately over the centre of the gabbro body, about 4.5 km from the ends. Elevations were scaled off a 1:50000 topographical contour map of the area and also entered into the MAGIXP™ program. The geomagnetic elements for 1987 of total field value of 54815 nT, a dip of 70.6° and a declination of 20.2° were used as the parameters of the inducing field. Profile B1 was first modelled by starting with a rectangular prism with vertical sides under the position of the half maximum amplitude value and then adding in more vertices until an approximate fit of calculated response to the observed values was obtained. Finally, the automatic inversion procedure using iterative methods was used to obtain body parameters for an optimum fit. The final model fit is shown in Plate SE2B and the coordinates of the vertices of the body listed in Appendix 4. While the fit of the calculated magnetic response over the main part of the exposed gabbro body is reasonable, the requirement of an extensive extension of the gabbro body to the northwest to explain the rise of magnetic field in this direction is less plausible. An alternative explanation for this northwest increase of magnetic values is that there are buried volcanics or intrusives of less magnetic susceptibility on this side of the gabbro body and the profile was remodelled with the introduction of a second body representing this latter unit. The final model fit is shown in Plate SE4B. The gabbro body has a maximum thickness of approximately 3500 m, thinning towards the flanks, and a thicker pile (> 5000 m) of volcanic or intrusive rocks on the northwest, with a magnetic susceptibility of 0.0209 S.I. units.



AFROMAGNETIC TOTAL FIELD MAP OVER STEWARTON GABBRO

MAP 2





AEROMAGNETIC TOTAL FIELD MAP OVER STEWARTON GABBRO

MAP 2



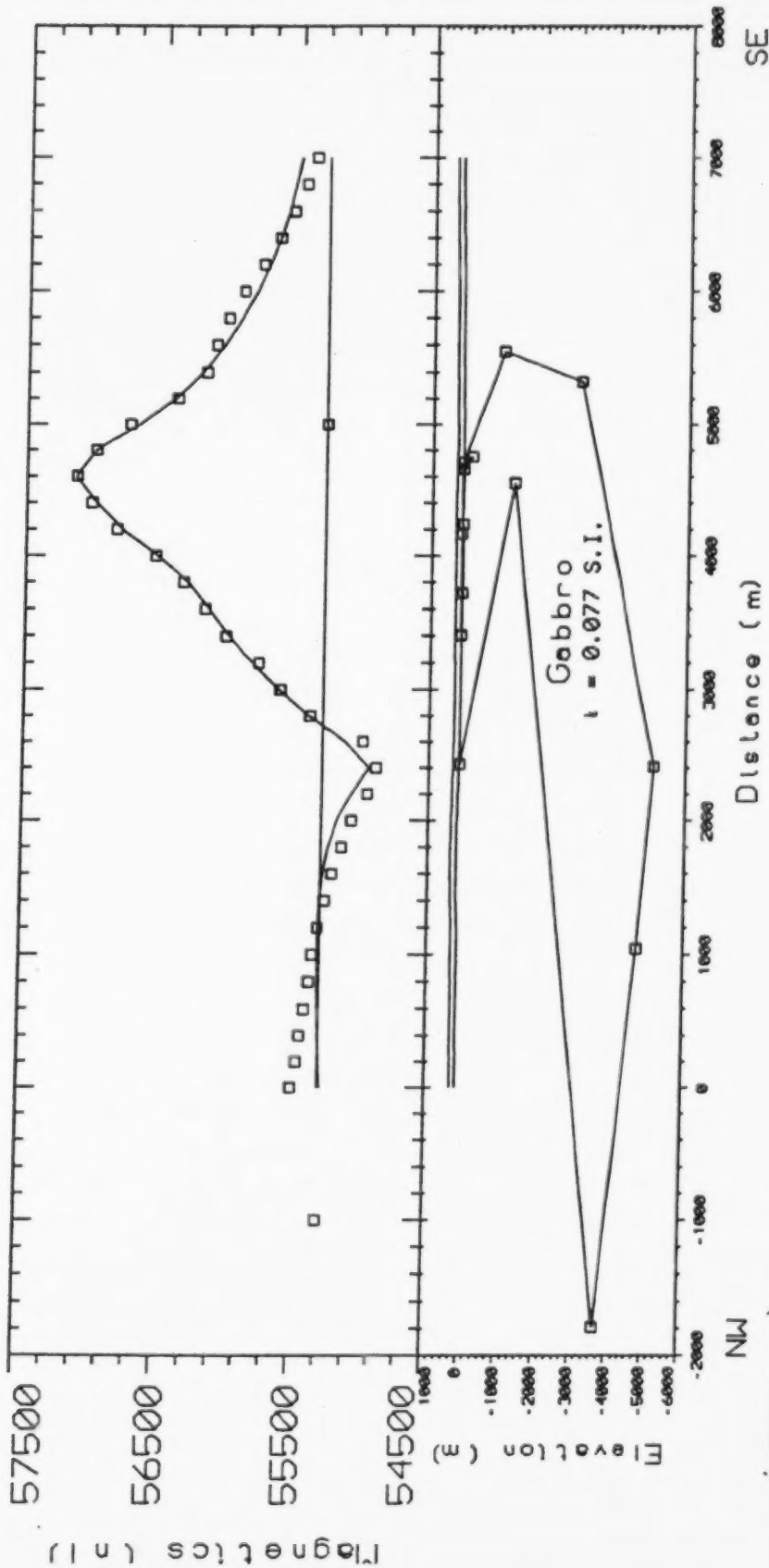
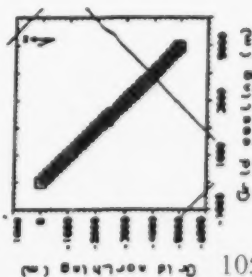


Plate: SE2B

Inducing field : 54815. nT		DNRE		Gabbro body	
Decl: 78.00 deg		Date: -28.28 deg		Stewarton 21H/13	
Strike Direction: 45.00 de		Date Set: 8/14/2011		Kings, N.B.	
Profile Direction: 130.00 de		Date: 28-AUG-00			
All Directions are Graticles from true north		Map Scale: 1:25000		Profile: B1-B1	
				Profile Scale: 1:40000 Vert. Exag: 5.28:1	



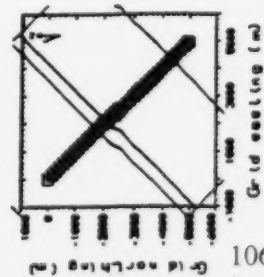
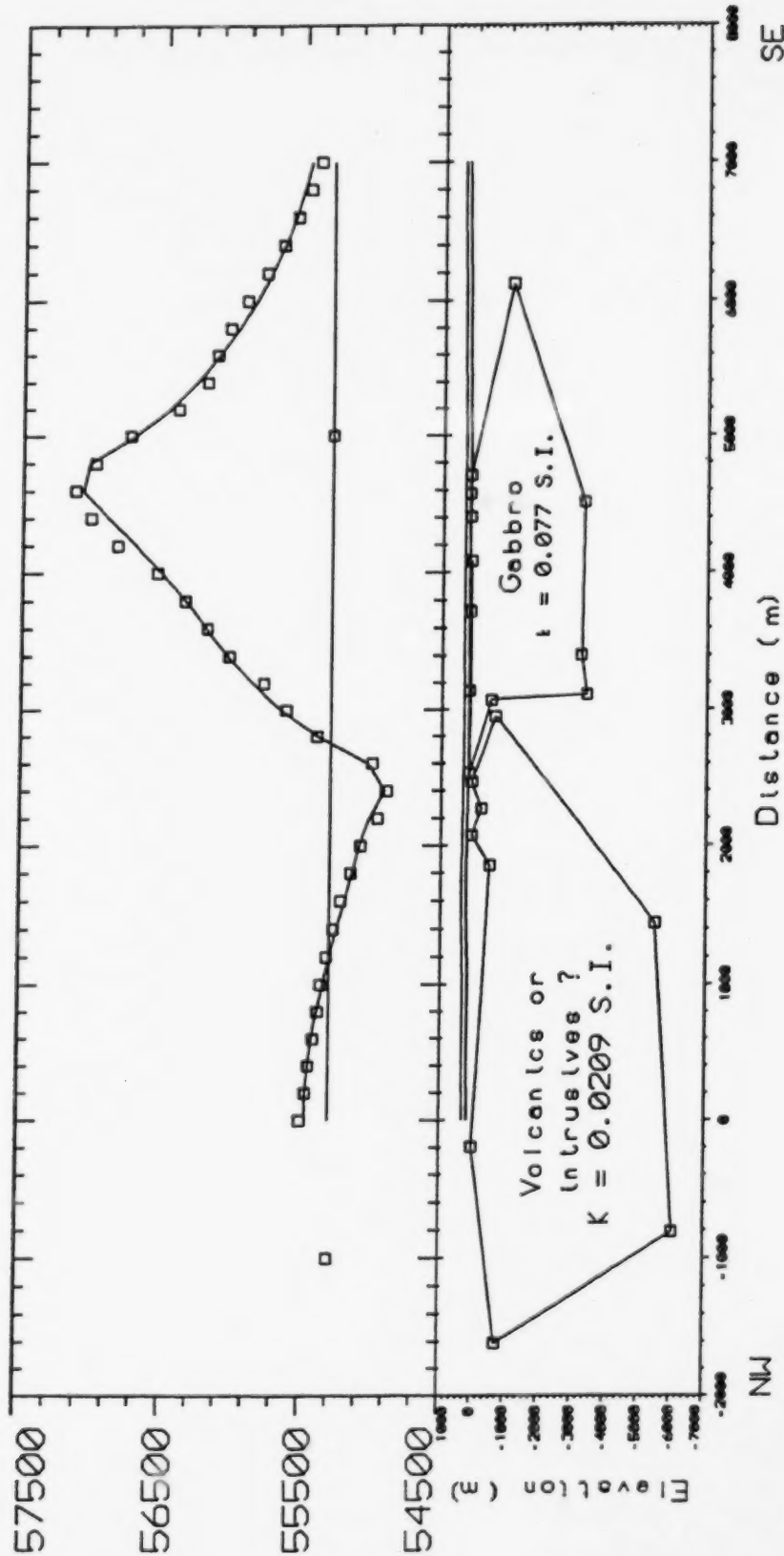


Plate: SE4B

Inducing field : 54815. nT		DNRE		Gabbro body	
Loc: 70.00 deg Dec: -20.20 deg		University of New Brunswick		Stewarton 21H/13	
Strike Direction : 45.00 de		Date Set: 9/14/81		Kings, N.B.	
Profile Direction : 135.00 de		Date Set: 20-AUG-80		Profile Set: 11-0812 Ver. 1. Engr: 0.2411	
All Directions are Gradients from true north		Profile Set: 11-0812 Ver. 1. Engr: 0.2411			

Profile A1.

This profile was taken along the northwest - southeast flight line of the survey that was closest to the road between Joliffs Brook and Scotch Mountain (Map 4), because this latter road was the location of a traverse of gravity stations. The profile was positioned about 1 km from the northeastern end of the gabbro body and 8 km from the southwestern end. The geomagnetic elements for 1987 of total field value of 54815 nT, a dip of 70.6° and a declination of 20.2° were used as the parameters of the inducing field. The final model fit is shown in Plate MEA1 and the coordinates of the vertices of the body listed in Appendix 4. The gabbro body has a latholithic shape with a maximum thickness of 700 m, indicating a thinning of the body along the strike direction. Please note that this interpretation was made before elevation information was available.

Next, the Bouguer gravity values obtained along the adjacent road were plotted and the traverse data entered into the 2 3/4 magnetic/gravity modelling program MAGIXP™. A density of 2900 kgs/cu. m was adopted for the gabbro, based on measurements of samples collected in the Caledonia Highlands by Gupta and Burke (1977), and a density of 2650 kgs/cu. m was accepted for the country rock. The profile was first modelled by starting with a rectangular prism with vertical sides under the position of the half maximum amplitude value and then more vertices were added in until an approximate fit of calculated response to the observed values was obtained. Finally, the automatic inversion procedure using iterative methods was used to obtain body parameters for an optimum fit. The final model fit is shown in Plate SGA1 and the coordinates of the vertices of the body listed in Appendix 4. A similar latholithic shape to that of the magnetic interpretation was obtained, but with a maximum thickness of 850 m and different vertices.

The coordinates of the gabbro body found from the gravity modelling were entered into the magnetic module of the MAGIXP™ program and used to calculate the magnetic response along profile A1. The profile and model are shown in Plate MGEA. The amplitude of the calculated magnetic response is close to the measured values, but the fit on the northwest flank is poor. Arbitrarily chosen values of remanent magnetisation were then introduced into the model until the much better fit shown in Plate MGAR was obtained. This required the introduction of a remanent magnetisation of 0.3 of the induced magnetisation, with a dip of 10° and a declination of 160°. This ratio of remanent magnetisation to induced magnetisation (Konigsberger ratio) is typical for gabbros, but unfortunately no measurements of remanent magnetisation were available to check this interpretation.

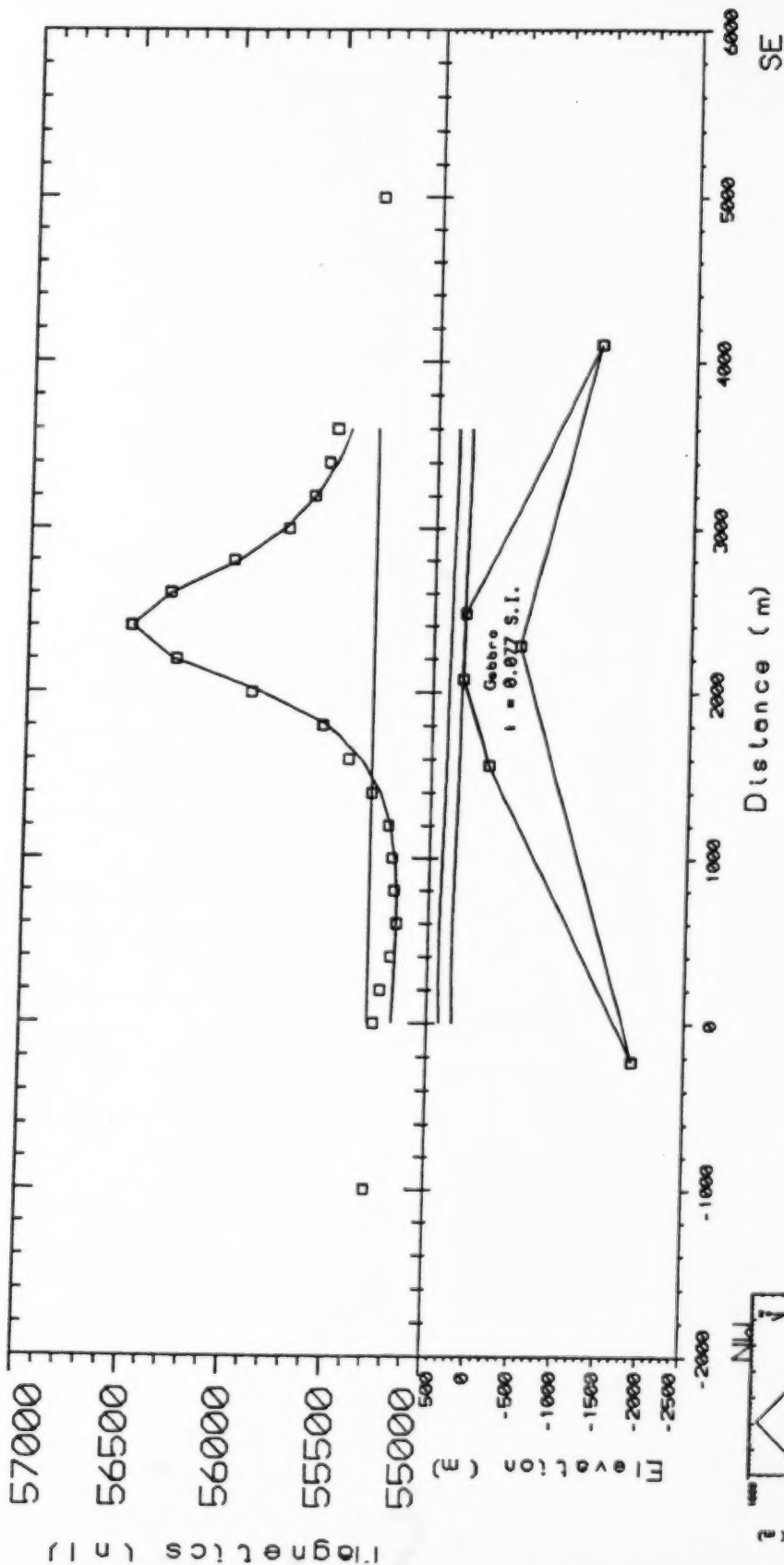


Plate: MEA1

Inducing field : 54815. nT	DNRE	Gabbro body
Incl: 76.66 deg Dst: -29.29 deg	University of New Brunswick	Stewarton 21H/13
Strike Direction : 45.00 de	Date Set: 8THG-A1	Kings, N.B.
Profile Direction : 135.00 de	Date: 21-AUG-00	Profile Set: 1120410 West, East: 6.521
All Distances are Distances from True earth	Profile: 11/2000	Profile: A-A'

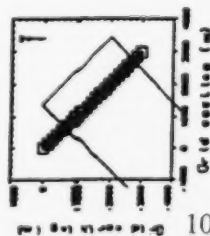
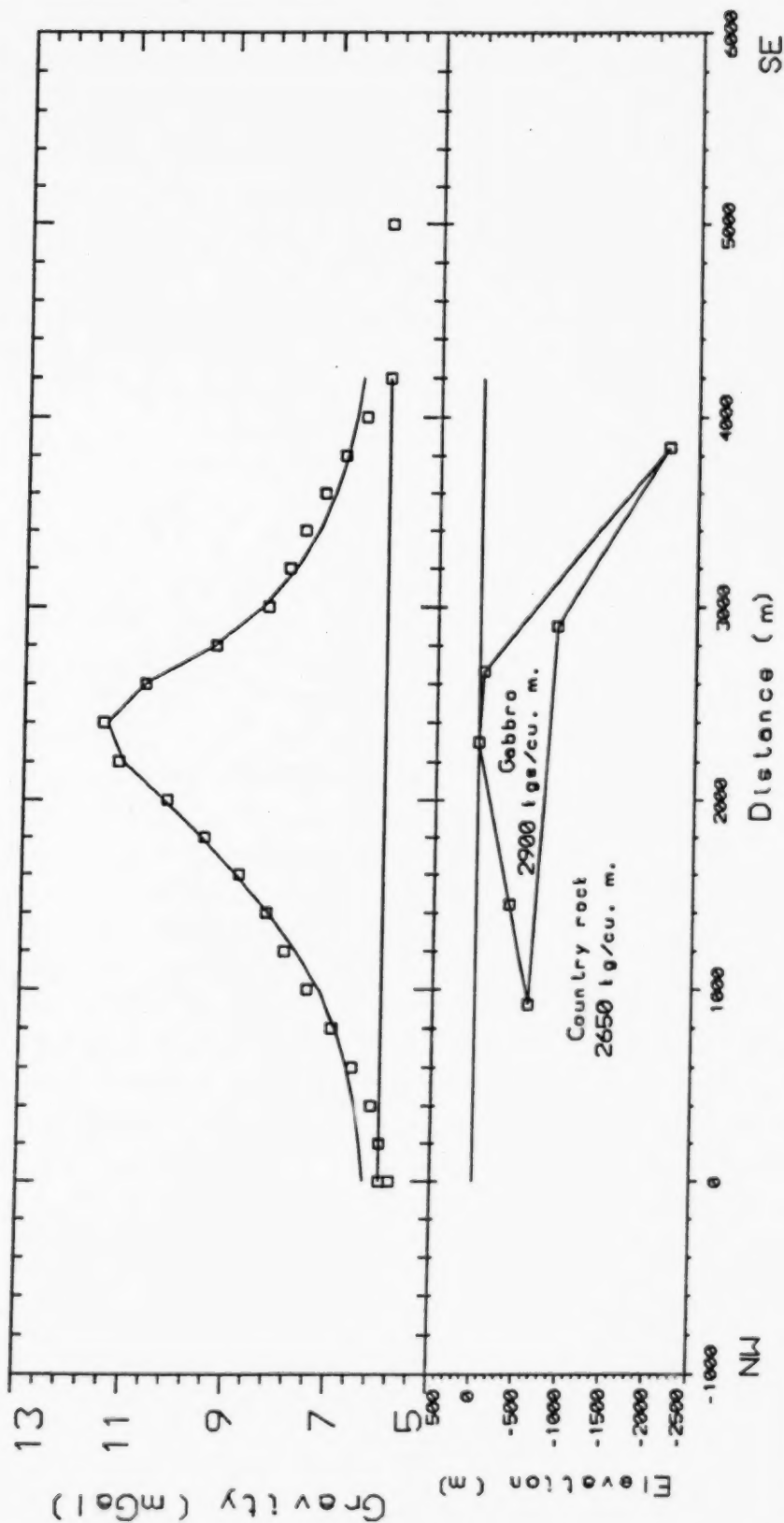


Plate: SGA1

DNRE

Gabbro body

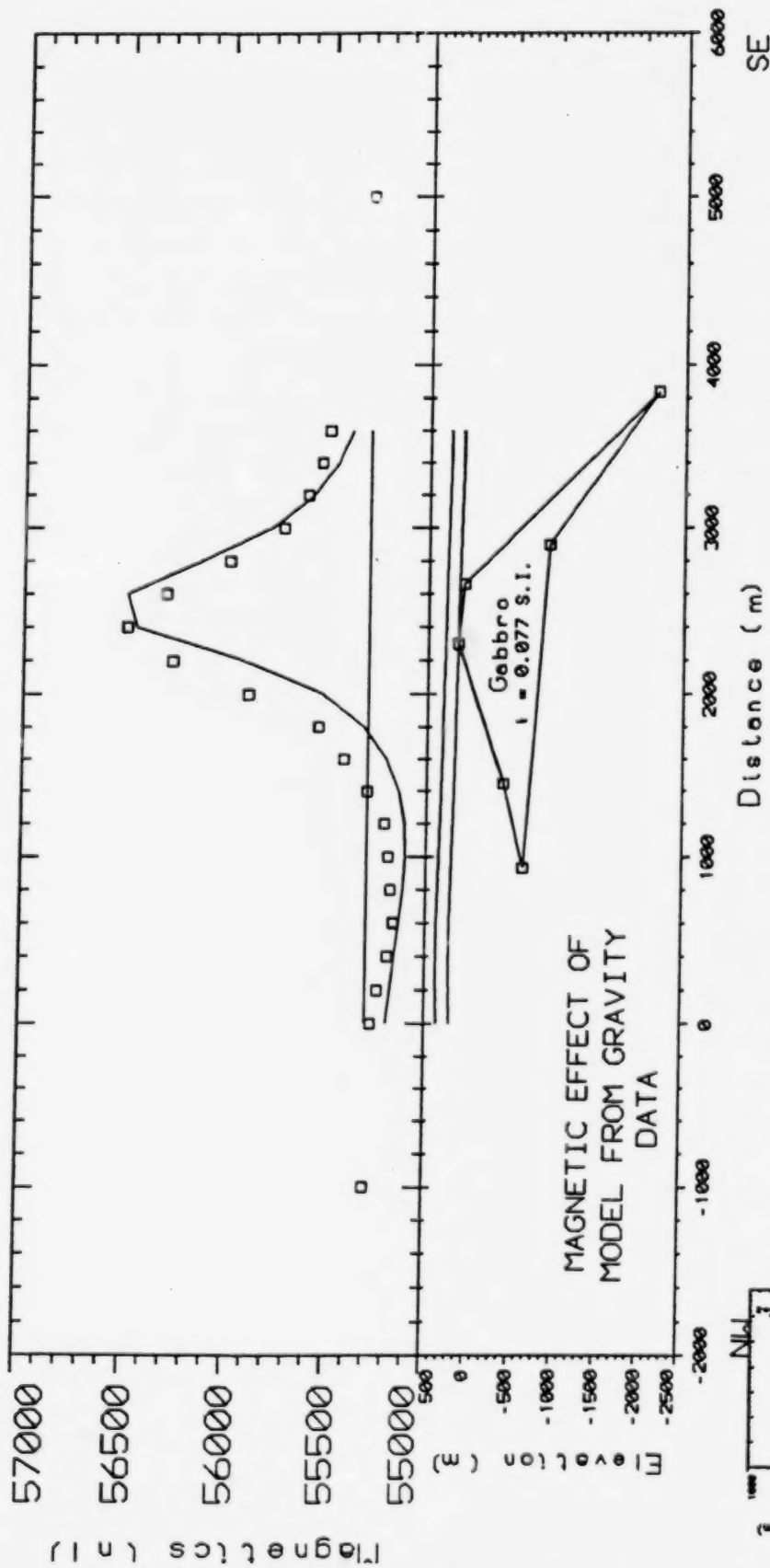
University of New Brunswick

Stewarton 21H/13
Kings, N.B.

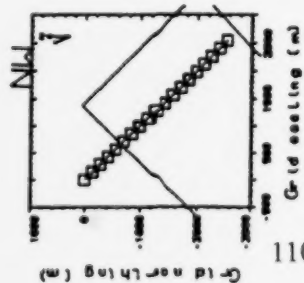
Date Set: STEUG-A1 Date: 22-AUG-00

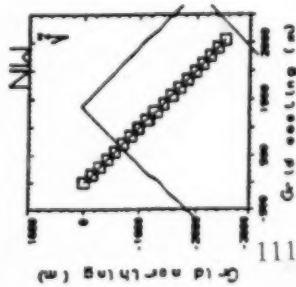
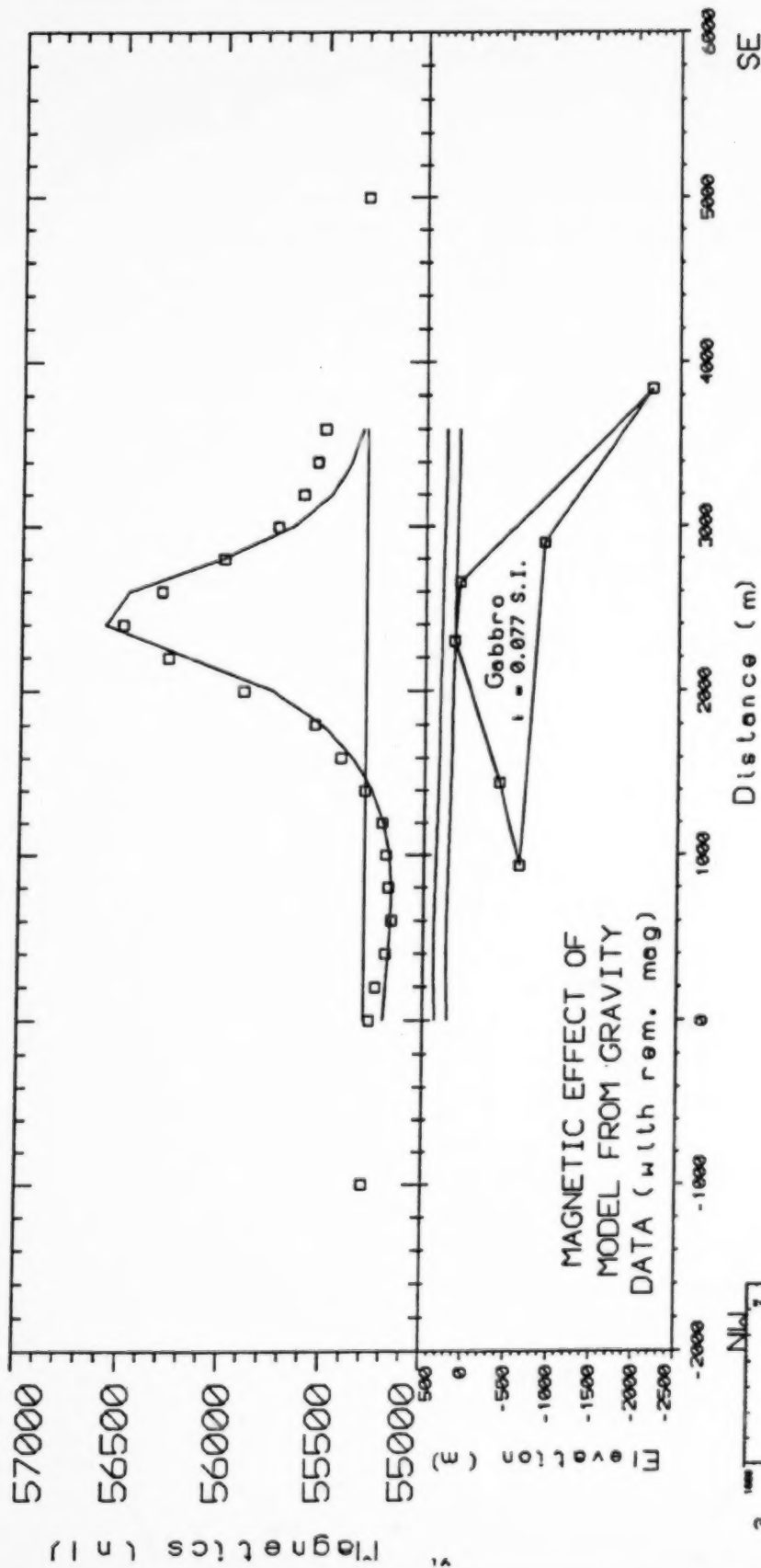
Map Scale: 1:215765 Profile: A-A'

Profile Scale: 1:33609 Vert. Exagg: 0.46:1



Inducing field : 54815. nT		DNRE		Gabbro body	
Inc: 70.00 deg Decl: -20.20 deg		University of New Brunswick		Stewarton 21H/13	
Strike Direction : 45.00 de		Date Set: 8/10/81		Kings, N.B.	
Profile Direction : 135.00 de		Map Sheet: 112500		Profile: A-A'	
All Directions are Estimated from Low earth		Map Sheet: 112500		Profile Sheet: 112500	





Inducing field : 54815. nT	DNRE	Plate: MGAR
Loc: 79.60 deg Dec: -20.20 deg	University of New Brunswick	Gabbro body
Sun (1) Direction : 45.00 deg	Date Set: 8TH/2008	Stewarton 21H/13
Profile Direction : 135.00 deg	Date: 22-AUG-09	Kings, N.B.
All Directions are Clockwise from True North	Map Scale: 1:125000	Profile Scale: 1:25000 North, Grapes: 0.0211
	Profile: A-A'	

Gravity data.

Gravity values and coordinates for the Stewarton area taken from Hassan (2000) were entered into the program Surfer™ and plotted in contour map form (see Appendix 5). Again, it was concluded that aliasing of most of the gravity anomalies had taken place because of the sparseness of stations and quantitative interpretation of the gravity anomalies would be unreliable. The one exception was the traverse of gravity stations along the Joliffs Brook to Scotch Mountain road, which was dealt with above.

Conclusions and recommendations.

Interpretation of a 1995 aeromagnetic survey over the gabbro bodies in the Lower Coverdale area yield models with latholithic shapes. Model fitting for 3 profiles shows bodies buried from 134 m to 164 m below the surface and thicknesses ranging between 800 m and 1100 m. Magnetic susceptibility values range between 0.00011 S.I. units and 0.172 S.I. units with a mean of 0.053592 S.I. units and a standard deviation of 0.051102 S.I. units. Sparseness of gravity stations in the area causes aliasing of gravity anomalies and prevented a combined interpretation of gravity and magnetic data, but a single seismic reflection section over the western edge of the eastern gabbro confirms the latholithic shape.

Interpretation of a 1987 aeromagnetic survey over the Stewarton gabbro shows that the outcrop edges are well mapped by the vertical gradient data. Magnetic susceptibility values range between 0.0301 S.I. units and 0.1041 S.I. units with a mean of 0.07674 S.I. units and a standard deviation of 0.029021 S.I. units. Model fitting of 2 profiles of the magnetic total field data yields a latholithic shape with a thickness of over 3500m in the centre of the body. The same latholithic shape was obtained from an interpretation of gravity data mapped along a profile about 1 km from the northeast end of the gabbro, but with a reduced thickness of about 850m. Comparison of the total magnetic field profile calculated from this gravity derived model to the observed magnetic data shows a reasonable fit, discrepancies on the northwest flank being explainable by remanent magnetisation in the gabbro.

Recommendations for future work are as follows:

- 1) Digital files of magnetic, gravity, geological information and elevations should be assembled in order to eliminate the necessity of graphically estimating values from contour maps of different scales.
- 2) A study should be made of the magnetic minerals of the gabbros, combined with measurements of remanent magnetisation.

- 3) Gravity traverses should be made across the gabbro bodies to provide more data for combined magnetic and gravity interpretation.
- 4) Magnetic susceptibility and density measurements should be made for the gabbros and surrounding country rocks.

References.

- Burke K.B.S. 1989. Report on three aeromagnetic anomalies, southeast of Moncton, New Brunswick. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Open File Report 89-4, 21 p.
- Burke K.B.S. 1995. Interpretation of aeromagnetic anomalies as aggregate sources in southeastern New Brunswick, Consultant report to New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, 57 p.
- Gupta V.K. and K.B.S. Burke 1977. Density and magnetic susceptibility measurements in southeastern New Brunswick. Canadian Journal of Earth Sciences, Vol. 14, pp. 128-132.
- Hassan H.H. 2000. Digital compilation of gravity data for New Brunswick. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Open File Report 2000-1, 212 p. 2 maps (MP 99-33A & B). Digital files 2 diskettes.

APPENDIX 1

LCOVA102 MAGZ -20.700

DNRE

27-JUL-00

Lower Coverdale Moncton 211/2

A-A'

Albert, N.B.

Gabbro body

12.000	0.000	100.000	0.000	M	M
54714.000	70.600	45.000	135.000		

BODY: BACKGROUND SUSCEPTIBILITY: 0.000000E-01 \
EXTENT-OUT: 0.000000E-01 EXTENT-IN: 0.000000E-01 \
K-RATIO: 0.000000E-01 INCLINATION: 0.000000E-01 \
DECLINATION: 0.000000E-01

BODY: 1 SUSCEPTIBILITY: 5.359200E-02 \
EXTENT-OUT: 8.000000E+03 EXTENT-IN: 1.000000E+03 \
K-RATIO: 0.000000E-01 INCLINATION: 7.060000E+01 \
DECLINATION: -2.020000E+01

VERTEX NO.:	X:	Z:	FREE:	LOCKED TO:
-----	--	--	----	-----
VERT: 1	3.136326E+03	1.500000E+02	N	1
VERT: 2	4.272471E+03	2.372906E+02	B	2
VERT: 3	3.613312E+03	3.975826E+02	B	3
VERT: 4	3.561666E+03	1.120252E+03	B	4
VERT: 5	2.743857E+03	1.135014E+03	B	5
VERT: 6	2.346521E+03	4.244897E+02	B	6
VERT: 7	2.728083E+03	2.326847E+02	B	7

LCOVB102 MAGZ -20.700
 DNRE
 Lower Coverdale Moncton 21I/2
 Albert, N.B.
 Gabbro body

18-AUG-00
 B-B'

12.000	0.000	100.000	0.000	M	M
54714.000	70.600	180.000	90.000		

BODY: BACKGROUND SUSCEPTIBILITY: 0.000000E-01 \
 EXTENT-OUT: 0.000000E-01 EXTENT-IN: 0.000000E-01 \
 K-RATIO: 0.000000E-01 INCLINATION: 0.000000E-01 \
 DECLINATION: 0.000000E-01

BODY: 1 SUSCEPTIBILITY: .5.359200E-02 \
 EXTENT-OUT: 1.500000E+03 EXTENT-IN: 1.500000E+03 \
 K-RATIO: 0.000000E-01 INCLINATION: 7.060000E+01 \
 DECLINATION: -2.070000E+01

VERTEX NO.:	X:	Z:	FREE:	LOCKED TO:
-----	--	--	-----	-----
VERT: 1	1.886672E+03	1.641167E+02	B	1
VERT: 2	2.291948E+03	1.620170E+02	B	2
VERT: 3	2.668323E+03	2.106290E+02	B	3
VERT: 4	2.684703E+03	1.035891E+03	B	4
VERT: 5	3.198899E+03	1.266885E+03	B	5
VERT: 6	2.516828E+03	1.259132E+03	B	6
VERT: 7	1.826463E+03	1.156313E+03	B	7
VERT: 8	4.796403E+02	6.024605E+02	B	8
VERT: 9	1.018977E+03	6.042570E+02	B	9

LCOVC102 MAGZ -20.700

DNRE

18-AUG-00

Lower Coverdale Moncton 21I/2

C-C'

Albert, N.B.

Gabbro body

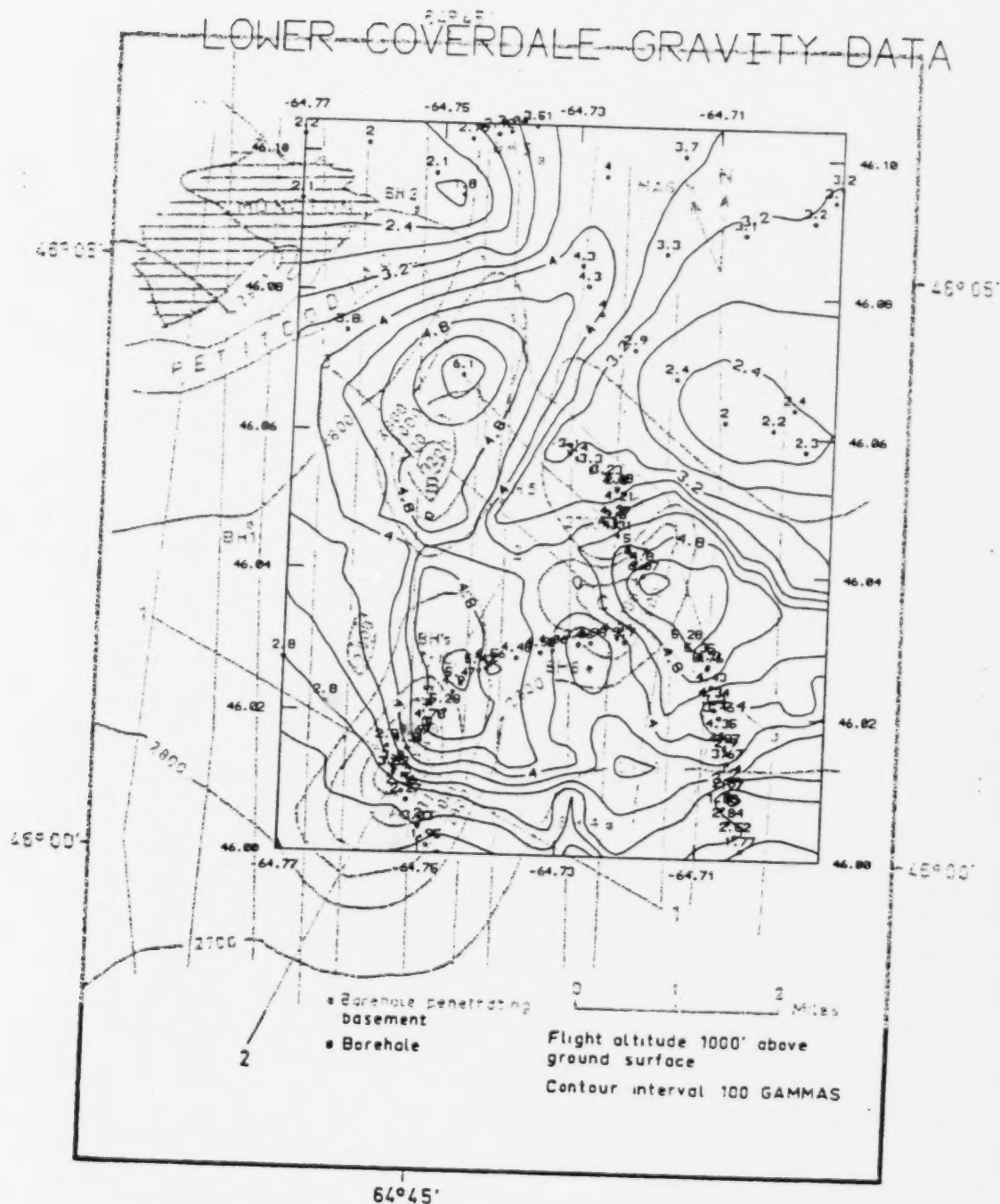
12.000	0.000	100.000	0.000	M	M
54714.000	70.600	45.000	135.000		

BODY: BACKGROUND SUSCEPTIBILITY: 0.000000E-01 \
EXTENT-OUT: 0.000000E-01 EXTENT-IN: 0.000000E-01 \
K-RATIO: 0.000000E-01 INCLINATION: 0.000000E-01 \
DECLINATION: 0.000000E-01

BODY: 1 SUSCEPTIBILITY: 5.359200E-02 \
EXTENT-OUT: 1.500000E+03 EXTENT-IN: 1.500000E+03 \
K-RATIO: 0.000000E-01 INCLINATION: 7.060000E+01 \
DECLINATION: -2.070000E+01

VERTEX NO.:	X:	Z:	FREE:	LOCKED TO:
-----	--	--	----	-----
VERT: 1	2.226614E+03	1.364892E+02	X	1
VERT: 2	3.132798E+03	1.548985E+02	X	2
VERT: 3	3.899857E+03	1.335383E+02	X	3
VERT: 4	2.574583E+03	3.016385E+02	B	4
VERT: 5	2.329003E+03	7.080932E+02	B	5
VERT: 6	1.623305E+03	3.116301E+02	B	6

APPENDIX 2

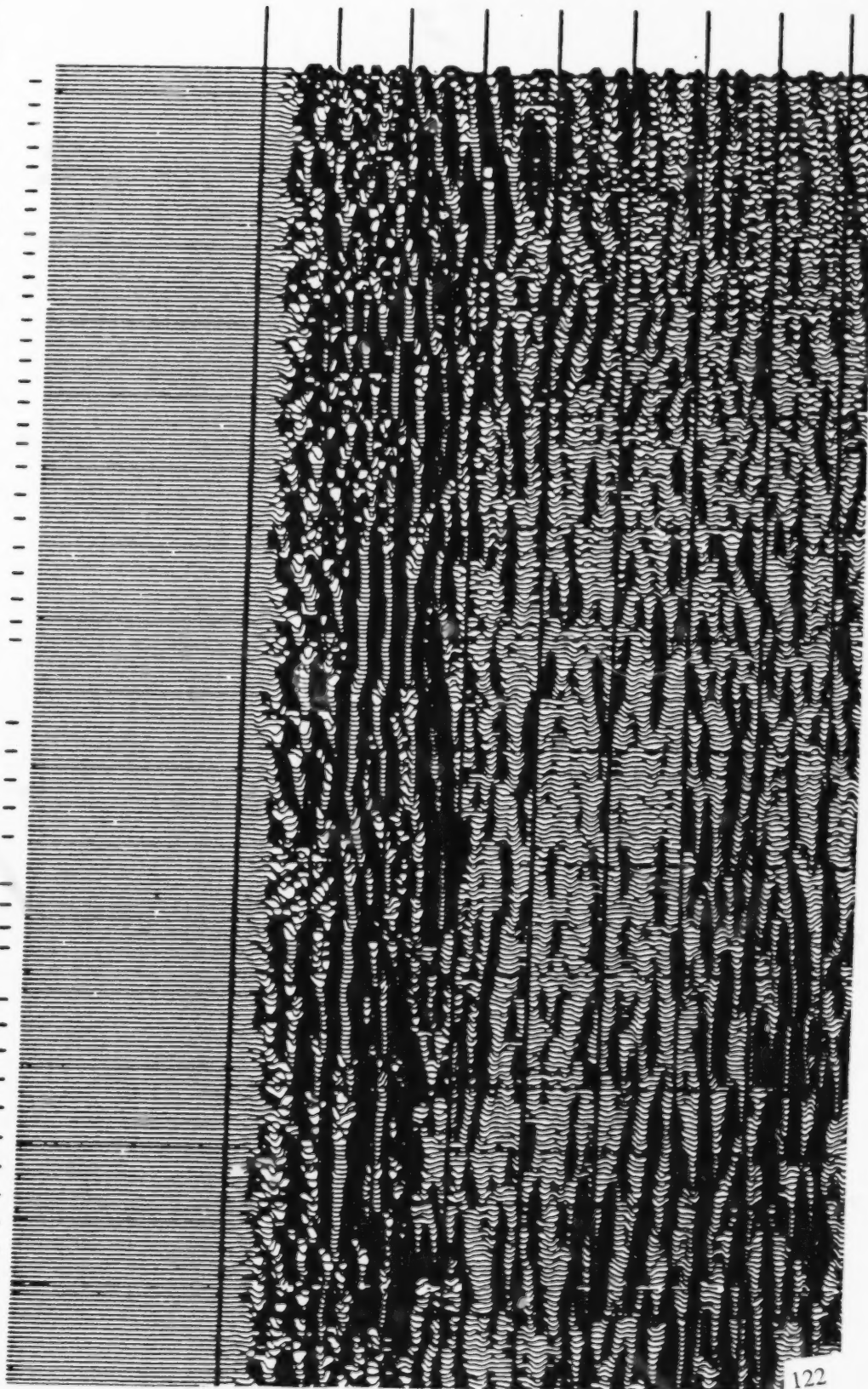


Aeromagnetic anomalies southeast of Moncton.

APPENDIX 3

SEISMIC REFLECTION PROFILE LINE 63 Y

3603 3624 3648 3676 3699 3726 SHOT POINT NUMBERS



APPENDIX 4

STWME2B1 MAGN -20.200

DNRE

28-AUG-00

Stewarton 21H/13

B1-B1

Kings, N.B.

Gabbro body

12.000	0.000	100.000	0.000	M	M
54815.000	70.600	45.000	135.000		

BODY: BACKGROUND SUSCEPTIBILITY: 0.000000E-01 \
EXTENT-OUT: 0.000000E-01 EXTENT-IN: 0.000000E-01 \
K-RATIO: 0.000000E-01 INCLINATION: 0.000000E-01 \
DECLINATION: 0.000000E-01

BODY: 1 SUSCEPTIBILITY: 7.674000E-02 \
EXTENT-OUT: 4.500000E+03 EXTENT-IN: 4.500000E+03 \
K-RATIO: 0.000000E-01 INCLINATION: 0.000000E-01 \
DECLINATION: 0.000000E-01

VERTEX NO.:	X:	Z:	FREE:	LOCKED TO:
-----	--	--	----	-----
VERT: 1	2.425242E+03	-1.606000E+02	B	1
VERT: 2	3.404530E+03	-1.669211E+02	B	2
VERT: 3	4.235479E+03	-1.511378E+02	B	3
VERT: 4	3.718354E+03	-1.609623E+02	N	4
VERT: 5	4.167991E+03	-1.855958E+02	B	5
VERT: 6	4.654531E+03	-1.513135E+02	B	6
VERT: 7	4.752312E+03	8.271533E+01	B	7
VERT: 8	4.707941E+03	-1.690000E+02	N	8
VERT: 9	5.552300E+03	9.134000E+02	N	9
VERT: 10	5.329980E+03	3.032481E+03	B	10
VERT: 11	2.410895E+03	5.148265E+03	B	11
VERT: 12	1.044452E+03	4.741186E+03	B	12
VERT: 13	-1.789681E+03	3.686258E+03	B	13
VERT: 14	4.550854E+03	1.236036E+03	B	14

STWME4B1 MAGN -20.200

DNRE

28-AUG-00

Stewarton 21H/13

B1-B1

Kings, N.B.

Gabbro body

12.000	0.000	100.000	0.000	M	M
54815.000	70.600	45.000	135.000		

BODY: BACKGROUND SUSCEPTIBILITY: 0.000000E-01 \
EXTENT-OUT: 0.000000E-01 EXTENT-IN: 0.000000E-01 \
K-RATIO: 0.000000E-01 INCLINATION: 0.000000E-01 \
DECLINATION: 0.000000E-01

BODY: 1 SUSCEPTIBILITY: 7.674000E-02 \
EXTENT-OUT: 4.500000E+03 EXTENT-IN: 4.500000E+03 \
K-RATIO: 0.000000E-01 INCLINATION: 0.000000E-01 \
DECLINATION: 0.000000E-01

VERTEX NO.:	X:	Z:	FREE:	LOCKED TO:
VERT: 1	3.071507E+03	5.047018E+02	B	1
VERT: 2	2.526945E+03	-1.465104E+02	B	2
VERT: 3	4.080185E+03	-1.306109E+02	B	3
VERT: 4	3.721429E+03	-1.560616E+02	X	4
VERT: 5	3.136502E+03	-1.698538E+02	B	5
VERT: 6	4.573839E+03	-1.821955E+02	B	6
VERT: 7	4.403632E+03	-1.603925E+02	B	7
VERT: 8	4.707941E+03	-1.690000E+02	N	8
VERT: 9	6.120492E+03	1.090266E+03	B	9
VERT: 10	4.507278E+03	3.278373E+03	B	10
VERT: 11	3.400608E+03	3.206037E+03	B	11
VERT: 12	3.109220E+03	3.383809E+03	B	12

BODY: 2 SUSCEPTIBILITY: 2.089700E-02 \
EXTENT-OUT: 4.500000E+03 EXTENT-IN: 4.500000E+03 \
K-RATIO: 0.000000E-01 INCLINATION: 0.000000E-01 \
DECLINATION: 0.000000E-01 FREE

VERTEX NO.:	X:	Z:	FREE:	LOCKED TO:
VERT: 13	-8.125891E+02	6.052166E+03	B	13
VERT: 14	1.437991E+03	5.488453E+03	B	14
VERT: 15	2.947970E+03	6.365530E+02	B	15
VERT: 16	2.463723E+03	-6.493118E+01	B	16
VERT: 17	2.266646E+03	2.110312E+02	B	17
VERT: 18	2.074878E+03	-6.770289E+01	B	18
VERT: 19	1.855073E+03	4.788145E+02	B	19
VERT: 20	-1.943941E+02	-4.260475E+00	B	20
VERT: 21	-1.613907E+03	7.500593E+02	B	21

STWME-A1 MAGN -20.200

DNRE

21-AUG-00

Stewarton 21H/13

A-A'

Kings, N.B.

Gabbro body

12.000	0.000	100.000	0.000	M	M
54815.000	70.600	45.000	135.000		

BODY: BACKGROUND SUSCEPTIBILITY: 0.000000E-01 \
EXTENT-OUT: 0.000000E-01 EXTENT-IN: 0.000000E-01 \
K-RATIO: 0.000000E-01 INCLINATION: 0.000000E-01 \
DECLINATION: 0.000000E-01

BODY: 1 SUSCEPTIBILITY: 7.674000E-02 \
EXTENT-OUT: 8.000000E+03 EXTENT-IN: 1.000000E+03 \
K-RATIO: 0.000000E-01 INCLINATION: 0.000000E-01 \
DECLINATION: 0.000000E-01

VERTEX NO.:	X:	Z:	FREE:	LOCKED TO:
----	--	--	----	-----
VERT: 1	2.078737E+03	-1.480000E+02	X	1
VERT: 2	2.476547E+03	-1.350000E+02	X	2
VERT: 3	4.105415E+03	1.390024E+03	B	3
VERT: 4	2.284693E+03	4.974466E+02	B	4
VERT: 5	-2.273513E+02	1.890442E+03	B	5
VERT: 6	1.562865E+03	1.611151E+02	B	6

STEWG-A1 GRAV 0.000

DNRE

22-AUG-00

Stewarton 21H/13

A-A'

Kings, N.B.

Gabbro body

12.000	0.000	100.000	0.000	M	M
50000.000	65.000	45.000	135.000		

BODY: BACKGROUND DENSITY: 2.650000E+03 \
EXTENT-OUT: 0.000000E-01 EXTENT-IN: 0.000000E-01

BODY: 1 DENSITY: 2.900000E+03 \
EXTENT-OUT: 8.000000E+03 EXTENT-IN: 1.000000E+03

VERTEX NO.:	X:	Z:	FREE:	LOCKED TO:
-----	--	--	----	-----
VERT: 1	2.299835E+03	8.545399E-03	B	1
VERT: 2	2.663526E+03	4.987919E+01	B	2
VERT: 3	3.843155E+03	2.162483E+03	B	3
VERT: 4	2.901708E+03	8.964266E+02	B	4
VERT: 5	9.250504E+02	6.182143E+02	B	5
VERT: 6	1.444109E+03	3.854450E+02	B	6

STWMGEA1 MAGN -20.200

DNRE

21-AUG-00

Stewarton 21H/13

A-A'

Kings, N.B.

Gabbro body

12.000	0.000	100.000	0.000	M	M
54815.000	70.600	45.000	135.000		

BODY: BACKGROUND SUSCEPTIBILITY: 0.000000E-01 \
EXTENT-OUT: 0.000000E-01 EXTENT-IN: 0.000000E-01 \
K-RATIO: 0.000000E-01 INCLINATION: 0.000000E-01 \
DECLINATION: 0.000000E-01

BODY: 1 SUSCEPTIBILITY: 7.674000E-02 \
EXTENT-OUT: 8.000000E+03 EXTENT-IN: 1.000000E+03 \
K-RATIO: 0.000000E-01 INCLINATION: 0.000000E-01 \
DECLINATION: 0.000000E-01 FREE

VERTEX NO.:	X:	Z:	FREE:	LOCKED TO:
-----	--	--	----	-----
VERT: 1	2.298000E+03	-1.480000E+02	N	1
VERT: 2	2.658000E+03	-1.350000E+02	N	2
VERT: 3	3.836700E+03	2.176000E+03	N	3
VERT: 4	2.899000E+03	9.040000E+02	N	4
VERT: 5	9.340000E+02	6.300000E+02	N	5
VERT: 6	1.448000E+03	3.930000E+02	N	6

STWMGEAR MAGN -20.200

DNRE

22-AUG-00

Stewarton 21H/13

A-A'

Kings, N.B.

Gabbro body

12.000	0.000	100.000	0.000	M	M
54815.000	70.600	45.000	135.000		

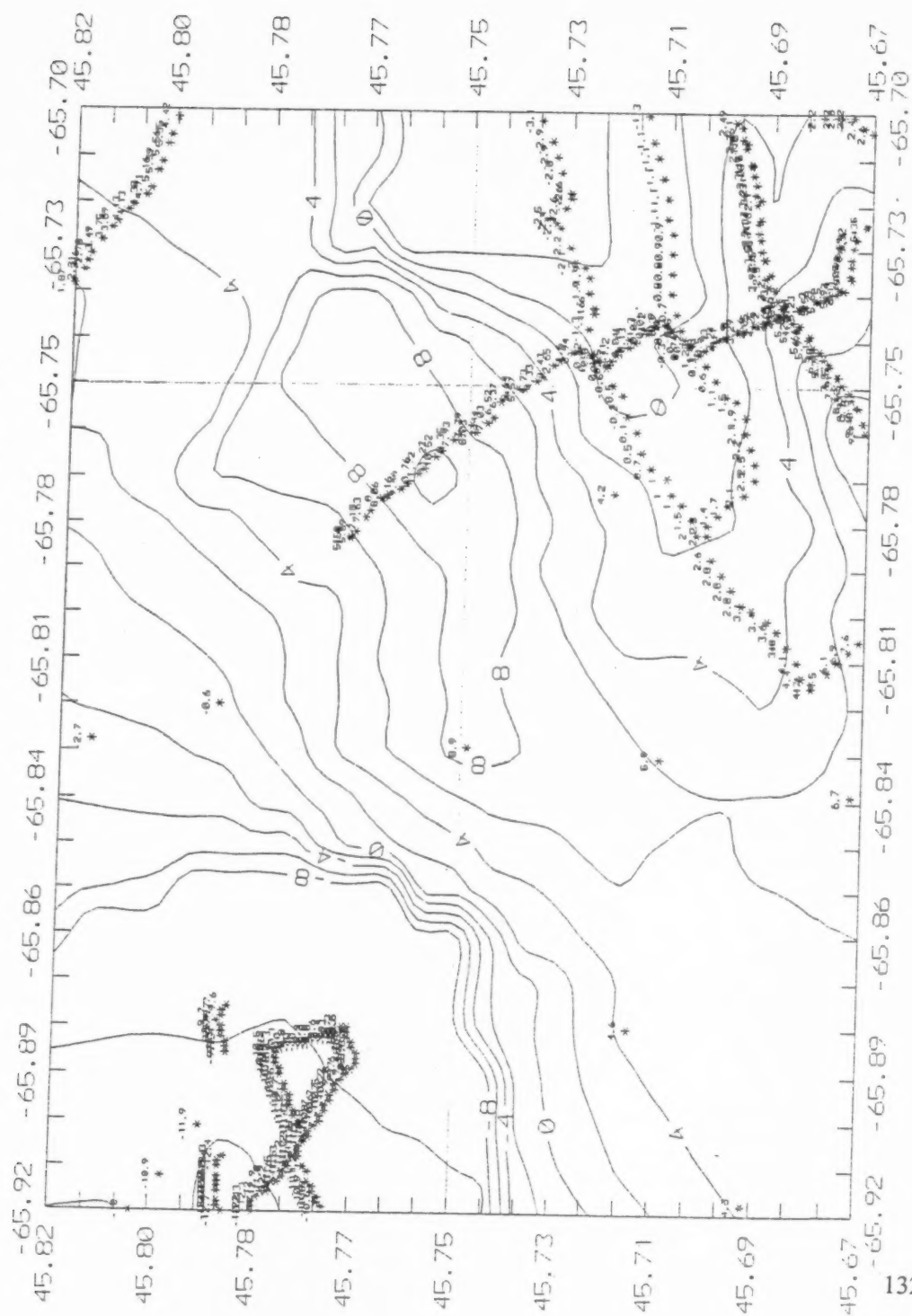
BODY: BACKGROUND SUSCEPTIBILITY: 0.000000E-01 \
EXTENT-OUT: 0.000000E-01 EXTENT-IN: 0.000000E-01 \
K-RATIO: 0.000000E-01 INCLINATION: 0.000000E-01 \
DECLINATION: 0.000000E-01

BODY: 1 SUSCEPTIBILITY: 7.674000E-02 \
EXTENT-OUT: 8.000000E+03 EXTENT-IN: 1.000000E+03 \
K-RATIO: 3.000000E-01 INCLINATION: 1.000000E+01 \
DECLINATION: 1.600000E+02

VERTEX NO.:	X:	Z:	FREE:	LOCKED TO:
-----	--	--	-----	-----
VERT: 1	2.298000E+03	-1.480000E+02	N	1
VERT: 2	2.658000E+03	-8.600000E+01	N	2
VERT: 3	3.836700E+03	2.176000E+03	N	3
VERT: 4	2.899000E+03	9.040000E+02	N	4
VERT: 5	9.340000E+02	6.300000E+02	N	5
VERT: 6	1.448000E+03	3.930000E+02	N	6

APPENDIX 5

STEWARTON GRAVITY DATA



MAPS

NOT FILMED

CARTES

NON FILMÉ

Micromedia
ProQuest

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Toll Free: 1-800-387-2689
Fax: (416) 362-6161
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